

Sir ISAAC NEWTON's

THEORY *grrk*

OF

LIGHT *and* COLOURS,

AND HIS

Principle of Attraction,

Made familiar to the LADIES in
several ENTERTAINMENTS.

Translated from the Original *Italian* of
Signor *Algarotti*.

Quæ legat ipsa Lycoris.

VIRG. Ecl. X.

V O L . H.

L O N D O N :

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THEORY

Light and Colour



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V O L. II.

ENTERTAINMENT IV.

E *Ncomium on Experimental Philosophy,
and an Exposition of the Newtonian
System of Optics.* Page 1.

ENTERTAINMENT V.

*A Continuation of the Exposition of NEW-
TON's Optics.* Page 75.

ENTERTAINMENT VI.

*An Exposition of Sir ISAAC NEWTON's
Universal Principle of Attraction. The
Application of this Principle to Optics.
The Conclusion.* Page 134.

CONTENTS

VOL. II.

ENTERTAINMENT IV.

E Newton on Experimental Philosophy,
and an Exposition of the Newtonian
System of Optics. Page 1.

ENTERTAINMENT V.

A Continuation of the Exposition of New-
ton's Optics. Page 75.

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Universal Principle of Attraction. The
Application of this Principle to Optics.
The Conclusion. Page 134.



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SIR ISAAC NEWTON'S
THEORY

OF
LIGHT and COLOURS, &c.

ENTERTAINMENT IV.

*Encomium on Experimental Philosophy;
and an Exposition of the Newtonian
System of Optics.*

EXT Day we continued our
Entertainments quietly, with-
out the Interruption of the
Captious of the Poets. 'Tis now
Madam, says I to the Marchioness, full
Time that I lead you into the Sanctuary of
Philosophy. 'Tis a sacred Place, where the
Profane are not admitted. None of those
Heads crouded with Vortexes, with Glo-
bules, with Atoms, with subtil Matter
and such Chimeras. You now, Madam,

VOL. II.

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are

are to explore a Philosophy, free from all such idle Pomp; but in Return it gives you no Expectations which it does not answer. Here we content ourselves with the genuine History of pure Nature, and leave to others the idle Care of such pompous Romances. You have already had a little Taste of this plain and modest Philosophy, in the Explanation of Vision; whereas, in the System of Vortexes, you have seen the absurd Impudence of that other Kind, which pretends to rise to first Causes; and laying the original Foundation of the World on such imaginary Principles, from thence pretend, according to their own Whim, to account for all the Appearances in Nature.

The vast Resemblance we find between the Eye and a darkened Room, may induce us to hope that for the future, Philosophers will agree pretty well in their Accounts of Vision. But then as to many other Properties of Bodies, such as *Weight*, *Hardness*, *Light*, and *Colours*, we cannot expect that they will agree so well. These Qualities come from more hidden Causes, which leave us little more than the Privilege of guessing; and you may imagine

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how dangerously idle it is, to pretend to guess at Nature, when she would conceal herself from us.

The Misfortune, which Globules and Vortexes have undergone, may make you very diffident, and raise in you great Suspicions about all Subjects of this Kind. These two Systems not only had their Reigns, but reigned with Applause; at last they are laid aside, and Nature herself has given them the Lie.

You must know that hitherto all general Hypotheses, which have been built on general Causes, have met with the same Misfortune, as Empires of too wide Extent, sooner or later, sink under the Weight of their own unmanageable Vastness.—

So, Sir, it seems, that this agreeable Interrogatory, *Why?* which so quickens and so flatters our Curiosity, must always remain concealed. Philosophers will never guess that is a Pleasure reserved for the Vulgar only. But in Reality you place them in a very hard Situation.—I answered, that, according to one of our most ingenious Writers, Guess-Work was allowed in no Science but in Geometry. For such is the Certainty of it's Principles, that if it does not lead directly

to the Point we have in View, at least it offers nothing repugnant to the Truth; and though we even fail of the Discovery proposed; something or other still occurs to reward us for our Pains.

But how much Incertainty? How much Inconstancy in *Natural Philosophy*? Some support Vacuums, and will have it that there are Spaces absolutely void of all Body; others again support an Universal Plenitude, and treat the Vacuum as merely chimerical. This Diversity of Opinions is an eternal Source of ridiculous Questions: Doubts grow on Doubts, till at last they come to question even the very Essence of Bodies, as well as dispute upon their Nature; and yet one would think that nothing in *Natural Philosophy* should be clearer. For nothing is so much the Object of Philosophical Enquiry, as Bodies and their Properties. Your presumptuous Philosophers are somewhat like learned Commentators, whose whole Time is spent in restoring the Readings of ancient Authors. This gives us the Text in such Order, That in another: Each supports his Readings by the most plausible Reasons in the World, and each in his Turn gains the Victory by the

the Suffrages of all the Connoisseurs and Journalists. At last an old original Manuscript is found among the Rubbish of some Library; the Author's true Sense appears, and all the imaginary Interpretations of the Scholiasts vanish; and the Time, which they had so profitably spent in the Search, flies away to the Moon of *Ariosto*, there to take it's Place among the lost Things of this Earth.

Nature too has her original Manuscripts, Experience and Observation, which every now and then overturn the most elegant Systems, and shew us how idle it is to attach ourselves to any one. But this is a Lesson we don't care to be obliged to her for. Men will go on in their own Way, and waste their Time as they think fit.

There, says the Marchioness, there's a fine Use to be made of Observations; the Moment the System discovers the least Ingenuity, Observations make War upon it. These one may call the *Erostratus's* of Philosophy, who only illustrate by overturning whatever is most beautiful in the Science. This is a Character that can never please me.

What will you say, Madam, when I tell you how far Observation can go, or what

it is capable of doing; there never yet was a System better founded on the Principles of Nature, than that which furnished Animals with Wings for flying, and Legs for walking. But yet by observing the Works of Nature we have discovered Insects, that have Wings and don't fly; and we have found others, who had Feet well placed and well formed, and yet move only on their Backs.—But yet, Madam, I will freely own to you, that I should think Observations of very little Use, if they served only for the Destruction of Systems. But in doing this, a thousand Benefits derive to us from them. 'Tis not only getting rid of an idle frivolous System on one Hand, but we immediately reap the Benefit on the other. For Instance, some melancholy Philosophers took it into their Heads, that the Rays of the Moon were cold and moist, and, as such, of dangerous Influence and to be shunned with Care.

Even at this Day People give into this old Nonsense, and run from their Walks to shut themselves up as soon as the Moon begins to shine upon them. Others complain of Heaviness in the Head, if by any Accident the Malignity of this Planet's Rays
has

has happened to reach them.—But thank God, from some late Experiments we are now left at Liberty to walk at all Hours, without any Danger from this once dreaded Malignity. The Rays of the Moon, either reflected from a Concave, or collected by a convex Glass have no sensible Effect upon Bodies, and yet in the Focus of either, they are two thousand Times denser than in the open Air.—A Thermometer, whose Liquor shrinks at the least Cold and dilates at the least Heat, when placed in the Foci of such Glasses before the Rays of the Moon, suffers no Kind of Alteration.—But these same Glasses, on the contrary, when placed in Rays of the Sun, will make a Coal burn with an Intensity of Heat infinitely beyond that of any Furnace. And even the *Amiant*, that was Proof to all the Fires of the Butchers of old, submits to this.—

From what has been said we may infer, that the Rays of the Moon are only to give us Light by Night, or else to diffuse around the Heart a softer Sadness, and those passionate Languishments which are the Delight of Love, and in these there is no Sort of Malignancy.

Well, Sir, as for these Observations we may

admit them ; they seem of themselves good, and besides they do no Dishonour to beautiful established Systems. We are moreover great Gainers by them ; for they save us from a great deal of groundless Uneasiness.

We are still a great deal more indebted to Observation, continued I, for ridding us of Fears of much greater Consequence, Showers of Blood, Comets, Pillars of Fire, *Will o'the Whisp*, all these were so many Prefages of the Wrath of Heaven, which at present are only the innocent Sports of Nature, and give us no Sort of Uneasiness. But if there be any Body still left that disquiets himself about them, they are People of mean Capacity, naturally superstitious in themselves, and always to be wrought on by the Superstition of others.

It were tedious to recount all the Advantages, for which we are indebted to Observation. To Observation we owe that the Sciences of *Astronomy*, *Anatomy*, and *Natural History*, seem rather to have taken Rise amongst the Moderns, than to have been transmitted to us by the Ancients.

To the Discoveries of Observation, we owe our Knowledge of the Blood's Circulation in *Anatomy*, and all the animal
Oeconomy,

Oeconomy, which, how simple soever it be, was very little known to the Ancients.

To the same Discoveries we are indebted in *Chemistry* for Phosphorus's; in *Astronomy* for exact Predictions; in *Hydrostatics*, for a Conveniency of Respiration under Water; in *Acoustics*, for Conveyances of Sound, for various musical Instruments, the Offspring of Harmony; for the Project of rendering our Hearing as perfect as our Sight; in *Optics*, for Spectacles, Telescopes, Microscopes, the Camera Obscura, the Magic Lanthorn, and so many other wonderful Operations that improve or indulge the Sense of seeing.

All these Inventions were unknown to the early Ages of the World. The Want of proper Means to make Discoveries, the Superstition and Credulity of the Times, and an unhappy Prejudice in Favour of what is marvellous rather than what is true, were invincible Obstacles to the Progress of the Sciences.

What Treasures have we not discovered in *Natural History*, since our Philosophers have acquired Resolution enough to reject the chimerical Systems of the Ancients. Formerly the marvellous was nothing but

Falshood. To Day we find it strictly agreeing with Truth. All is wonderful, all is true !

On which Side soever we turn our Eyes, we see none but Objects of Admiration, new Modes of engendering, of respiring, of seeing, and of living; new Organizations, new Societies, with which our Ancestors were utterly unacquainted.

We know some Animals which have no Sex, others which have both Sexes in themselves, but are yet incapable of propagating their Species alone; and others still, which without Assistance are enabled to produce their own Kind.

Our Reason and Understanding have received infinite Improvement, from thoroughly considering the Properties of Brutes. Arts have been brought to Perfection by happy Observations upon some Animals, which before were looked upon as the Refuse of Nature. Our Manufactures are obliged to Spiders for a new Kind of Silk, and a Pea of a certain Fish, as yet unknown to us, can, with a little Preparation, produce a Purple of a Lustre scarce inferior to the famous ancient *Tyrian Dye*.

Shall

Shall I mention to you the Experiments, which have been made on the Gravity of the Air; the Force with which it dilates itself; the Equilibrium of Fluids, and the Vegetation and Culture of Plants. These Experiments not only gratify our Curiosity, but are moreover the Sources of many Inventions, which have contributed to render Life more agreeable. They have embellished your Garden with it's *Jets d'Eaux*, and the soft Murmur of it's ornamental Fountains.

By a Train of these same Experiments, the Tables in *Northern* Climates are covered with the delicious Fruits, which Nature ordained the Produce of a more indulgent Hemisphere. The Orange of *Cbina*, transplanted to *Portugal*, becomes a cooling Relief against the intense Heats of Summer; and the *Rbenish* Vine, when growing on the burning Rocks of the *Canaries*, regales our Goddeffes with a more ravishing Nectar, than *Homer* boasts his Gods to have quaffed.

So then, replied she, we proceed finely; our System goes on better and better. Is not this the Grape of the Land of Promise? You find me here in the Country, you know what Pleasure I take in this Re-

12 Sir ISAAC NEWTON's *Theory*

treat, and have, doubtless, a Mind to gain me over by the Prospect of those Advantages, which Agriculture may draw from Observation. All this might have had it's Force with the Consuls of old, who, in their Retirement from triumphal Honour, did not disdain with their own Hands to till their Grounds.

If my Purpose had been to persuade you in that Stile, Madam, I had drawn my Arguments from those noble Arts you are so fond of, which owe their Origin and Progress to Observation and Imitation. For Instance, you admire the delicate Lineaments and fine turn of Visage in the *Medusa* of *Strozzi*; you are captivated with the exact Gradation observed in the Wrath of *Achilles*; with the Strength and Variety of the Passions in the Opera of *Cassandra*, that Master-piece of our modern *Timotheus*; You are struck with the majestic Solidity of the Portico of the Rotunda, with *Guido's* charming Manner, and the magick Colouring of *Rubens*. Well, it is to Observation you are obliged for all these Satisfactions: Be grateful and return her Thanks for them; that small Tribute at least she may justly challenge.

Be pleased, Madam, to recal to mind, continued I, all those new Beauties which have been added to the Treasure of Painting, by the Help of Observations upon Plants and Animals unknown to the Ancients. By Dint of Observation likewise we have discovered the Secret of the *Japanese* Varnish, which we now can imitate, and by this Means have brought to Perfection the Beauty of such precious Trifles, as, either through Pride or Luxury, are now become necessary.

And has not Poetry itself found an inexhaustible Source of striking Similitudes and shining Descriptions in these new Discoveries? We shall no more be pestered for the future with the frequent Repetition of the Sun, the Stars, country Swains, and *Hyrcean* Tygers: Those antiquated Metaphors, and tiresome common Places, shall be banished, and a Set of Images entirely new be introduced in their Stead.

Nor is this all, for Propriety, and what we call good Taste in Dress, the Care of our Persons; in a Word, that Art (of all others the most charming as it gives a Grace to and illustrates our natural Beauties;) that Art I say, so flattering, so soothing, is established

blished on the delicate Observations which have been made on Things the most capable of pleasing.

Permit me, Madam, to put you in mind of one farther Benefit arising from Observation. Beauty, which is in itself the most acceptable Gift of Heaven, were oftentimes an useless Present, if Art had not disclosed to us the Means of procuring for ourselves some certain Distempers. This Art though singular, though dreadful in Appearance, is not therefore less salutary. How many, as well fair *Circassians* as *Englisb* Beauties, have had their Charms preserved by the Inoculation of the Small-Pox, (an Operation performed by some skilful Hand in their tenderest Infancy,) without which Help, the former might seldom see fighting at their Feet the mighty Ruler of the Seraglio, and the latter perhaps have less Influence over Hearts accustomed to beat for Liberty only.—

But not to entertain you, Madam, with Things in which you may probably think that I allow my Arguments too great an Advantage; not to dwell any longer on *Physick* (in which Observation will always manifest it's shining Effects) is it not true likewise,
that

that *Politicks* are indebted to Observation for that glorious and wise System of Government, which renders the cloudy Regions of the *North* as blest as the clear Air of the *Southern* Sun, in reconciling the Liberty of the People to the Superiority of the Nobles, and both to the Authority of the Sovereign? Confess *Metaphysicks* also, that Labyrinth heretofore so dangerously intricate to Reason, have drawn from Observation that regular certain Plan of the Origin and Progress of our Ideas. How should we ever have been able to reduce to Order the Chaos of *Chronology*, and *History* unassisted by the Observations of Sir *Isaac Newton*? *Newton*, that divine Philosopher, who may well be esteemed the Founder of the Sciences!

Newton, by observing the course of Nature, has placed historical Facts in their proper Order: He brought nearer together some Epochas formerly set at too great a Distance by the Rashness and Pride, or Ignorance of Authors. In a Word, like an enlightened Geographer, who could to a Point mark the Bounds of the Earth, he ranged all Events in their true Position: Conducted by his observing Genius, he unfolded

folded to us (to use the Expression of one of his Countrymen) the shining Mantle of Day: He revealed the Properties of *Light* and *Colours*: He shewed us what is real and true, without amusing himself, like *Des Cartes*, in establishing an imaginary System to serve for an Explanation of their Causes.

You are going, Madam, to be introduced to a World quite new, quite enriched with the most charming Truths: *Newton* is the Discoverer: You will not find, throughout the whole, the least Track of preceding Philosophers. There cannot be a better Pattern of true Philosophy than his Treatise of *Opticks*, it was the Product of thirty Years Application and Study. One single Experiment of his gives more satisfactory Information, than one could formerly have received from all their best digested and most ingenious Systems.

In *Newton's* Theorems you will find a noble Simplicity and unadorned Truth, and you will even grow fond of it. An antique Column of the most worthless Stone will more captivate the Eye of a Connoisseur, and be of more real Use towards the Perfection of modern Architecture,

ture, than all that idle heap of Emeralds and Diamonds with which Poets crowd their fairy Palaces.

But, Sir, pray give me Leave; however well proportioned this antique Column may be, your Connoisseur will never admire it's Beauties properly, if he be not before-hand well informed wherein the exact Proportions of a Column consist, and from what Causes proceed the good or bad Taste of it. But setting this aside, be pleased, I pray you, to shew me how we can pretend to reason justly upon *Light* and *Colours*, without a Knowledge of their natural Causes, and of these, by your own Confession, the *English* Philosopher says not one Word.

We are told by *Des Cartes*, that the Rays of Light rebound from the Surfaces of Bodies, wherein (although his System be now exploded) I very well comprehend his Meaning. And whence is it, think you, that I do so clearly understand him? Why, because he began by telling me, that a Ray is nothing else but a Thread of little Globules. Now it must be by Miracle that I can be brought to conceive any of your new Discoveries about Light, if I am still left ignorant of what Light is.—What is there

there more inexplicable, replied I, than the Nature and Causes of Muscular Motion? In vain do Philosophers attempt to reason about such Matters; all their Arguments serve only to increase our Uncertainty, and yet a Master-painter, a *Michael Angelo*, supported only by repeated Observations, can without Hesitation tell which Muscles swell to View, and which sink and disappear in making this Motion or that Effort; inso-much that in all Attitudes, however uncommon, he can assign the infinite Variety of their Play. And for a Proof of this, one need only examine his Picture of the last Judgment in the *Vatican*.—The Load-Stone is a Secret of the same Kind; it's Nature and Causes of it's wonderful Effects are, and perhaps always will be, as great a Stumbling-block to Philosophers, as the *Punic* Language is to Scholars.

But notwithstanding this Ignorance of the Causes, we have the Pleasure to discover a great many useful Properties in the Load-stone. We know for Instance, that when cas'd with Steel, it's Power of attracting Iron becomes greater. We also know, that Load-stone will attract Load-stone on one Side, and repel it on the other.

But

But to crown all, we know that it's Poles correspond in their Direction with those of the Heavens, which Property alone opens a new Scene of Knowledge to Philosophy, to which we owe the Discovery of the Compass, and all it's Uses in Navigation.

Believe me, Madam, the true, the only Way to arrive at the pure Knowledge of Nature, as far at least as our Weakness will allow, is by attentive Observation and careful Search into the secret Properties of the Essence of Things ; for on these original ones all the others depend.

Till now you have only been conversant in the several Absurdities of those different Systems, which have successively owed their Rise to the Pride and vain Imagination of some Men, and their Reception to the Credulity of the People. Now *Newton* comes, who brings you Light and Truth, who speaks with Candour.

Pray lets hear them, says the Marchioness smiling. I wish with all my Heart they may be sufficient to remove the Cloud from before my Eyes. You now promise me a new Life of Philosophy : How charming will it be, how pleasing the Enjoyment of it while Truth is our Guide !

A Ray

A Ray of Light, Madam, as I have already told you, however subtil it may appear, pure and unmixed, is yet but a Collection of many others blended together; each distinctly of a different Colour, though when united in one single Ray, it appears whitish. Some of these are *Red*, some *Orange*, some *Yellow*, *Green*, *Azure*, *Indigo*, and *Violet*, besides innumerable Degrees of intermediate *Tints* between each of these seven principal Colours. Each of these Rays of different Colours we call primitive-homogeneous Rays; but when blended together they compose one heterogeneous Ray of a Colour not quite white, rather somewhat inclining to golden, such as a common Ray of Light appears. Such, or not very unlike it, is the intermingled Assemblage of Colours of a Painter's Pallet; there results from them, when blended, one new Colour, which in general partakes of all the rest, but differs from each in particular. You see, Madam, what Grounds that Poet, whom you discover rather by his Esteem for you than by his Style, had for the Expression in some Verses which you were pleased to make me repeat in our first Conversation. I believe you now thoroughly

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understand the Signification of the *Golden Light*, and the *Seven-fold*, an Epithet anciently appropriated to the *Nile* and the Shields of Heroes. This *Seven-fold Light* is the inexhaustible Source from which each different Object, throughout the Universe, derives that Colour with which it is clothed. It's Rays owe not to the Sapphire their beautiful blue, nor their Tincture to their Refraction through a Prism, or their Reflexion from the Surfaces of Bodies; but proceeding from the Sun with that Heat and Lustre which he communicates, each of them is adorned with it's own shining Colour, though imperceptible to our Eyes.—

In a Word, you must imagine that a Ray is the Assemblage of a prodigious Quantity of exceedingly subtil Threads, which have each it's own unchangeable Colour; and we can also plainly distinguish this Colour, when we see it separated from those others which concur with it in forming the white or yellowish Colour of Light. But what shall we say to the Skill and Penetration of that natural Philosopher, who knew how to take to Pieces this total Ray, and divide it into it's primary and elementary Rays, so as to make each shew it's proper Colour?

To

To say true, this Division could never be brought about were it not, that the homogeneous and primary Rays passing out of one Medium into another, as from Air into Glass, are by Nature more refrangible, some than others; for it is owing to their Inequality of Refraction alone, that they can be separated one from another. *Newton* was the Man that discovered this Difference of Refrangibility in Rays of different Colours, and upon this he founded his *Theory*. Experience afterwards taught him, that the *violet* Rays are the most refrangible of all. After them come in Order the *indigo* Rays, the *azure*, the *green*, the *yellow*, the *orange*, and lastly the *red*, which of all others is refracted the least. But am I distinct and clear enough, Madam, in my Explanation? Do you understand what I have the Honour to tell you?

Thoroughly, replied she, I can very clearly conceive, that Rays of different Colours may have different Degrees of Refrangibility. I understand likewise, how these different Degrees of Refrangibility, which they have from Nature, enable us to separate them, which without them we never could do. But you tell me, besides this,

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most surprising Things of your *Newtonian* Light. What an elevated Genius must he have had to attain to these Discoveries? I hope his Credit will be supported by weighty Arguments drawn from Observation: Pray satisfy my Impatience on this Head; produce me some Proofs, I long for them, I can't dissemble my Eagerness.— At first I inclined to *Des Cartes's* Opinion, then I fell into that of *Malbranche*, and now (what with your Observation-scheme) I am left without any System at all. This Void is disagreeable to me, and I expect from you some other Observations more pleasing to fill up the empty Space.

Madam, The Genius of Observation, depend upon it, will soon make you ample Amends for your present Chagrin, nor shall you wait long for that Satisfaction. Would to Heaven I could as easily gratify your good Taste in every Thing else! Be pleased to figure to yourself a Chamber entirely dark, a Chamber, in which, as *Milton* says, *reigns Darknefs visible*. This shall be our Scene for the Search of Truth. Let us make an Hole in the Window Shutter to admit a Ray of Light, and apply horizontally to this Ray a Prism of Glass which
may

may refract it. The refracted Ray will immediately strike upon the Wall opposite to the Window; so that in parting from the Prism, it takes an almost horizontal Direction parallel to the Floor of the Chamber: Whereas if it had not been refracted, if nothing had turned it aside from it's Course, it would have fallen upon the Floor, where it would have left a Mark of a whitish Colour and roundish Figure.

That Spectrum, or Image of the Sun, which the refracted Ray forms upon the Wall, is very different from that which the direct Ray formed upon the Pavement. For as the Image of the direct Ray was almost round and entirely white, that of the refracted Ray is of a Figure nearly resembling a Fish at Cards, longer than it is broad, and varied with an infinite Number of Colours, among which the seven primary ones are distinguished and placed in a shining Order, one after another.

The jolly Peacock spreads not half so fair
The eyed Feathers of his pompous Train,
Nor golden *Iris* so bends in the Air
Her twenty colour'd Bow through
Clouds of Rain.

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I am very glad to find that *Tasso*, said the Marchioness, who had before a little transgressed against the Laws of Refraction, for the sake of his *Armida*, has amended his Fault, and is at present reconciled to *Optics*.

These *Colours*, answered I, with which the Image is painted, are disposed in such a Manner, that the *Red* is in it's lower Extremity ; above this is placed the *Orange*, afterwards the *Yellow*, then the *Green*, the *Blue*, *Indigo*, and lastly the *Violet* ; which is placed in the upper Part of the Image.

Innumerable Degrees of intermediate *Colours* insensibly connect and unite the *Seven primary ones*. Neither *Correggio Tizian*, nor his Rival *Rosalba*, did ever unite and shade their *Metzo Tintoes* with so much Exactness to form the Oval of a Face.

In order to explain this great Change, we must suppose one of these two Cases, either that *Light* is composed of Rays differently coloured, and differently refrangible, so that the *Prism* does nothing but separate them from each other, when they are transmitted through it ; and by this Means the different *Colours* are formed, and the Image, which would otherwise be round, is of an oblong Figure.

This is one Manner of explaining this Phænomenon ; the other is, that the Light, in passing through a Prism, acquires Colours which it had not before ; and moreover, that every Ray is shattered, dilated, and split into many other diverging Rays, painted of a different Colour ; and this is the Reason why the Image is coloured and of an oblong Figure.

This last is the Supposition of *Grimaldo* a Philosopher, who preceded Sir *Isaac Newton* ; and this System is called the *Dispersion of Light*. You see it is necessary unless we admit the different Refrangibility to suppose this Dispersion, in order to explain, why the coloured Image of the Sun should have a Length much greater than it's Breadth, after being refracted by the Prism.

What then, said the Marchioness ! This Experiment, it seems, which has cost me so much Attention to understand, and this Oblongitude of the solar Image, are not sufficient to prove the different Refrangibility ; because all this Phænomenon may be as well explained by *Grimaldo's* Dispersion of the Light, which is a System very different from Sir *Isaac Newton's*. I want to see

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see some Experiment which cannot possibly be explained by any other System than the *Newtonian*, and that I believe would satisfy me. This, answered I, is the very Thing necessary to prove not only the different Refrangibility, but every other Principle in *Natural Philosophy*; and this Sir *Isaac Newton* has done, (without knowing perhaps that it would one Day give Pleasure to a fine Lady) whatever a certain Author may say to the contrary, who accuses him with having drawn more Consequences from his Observations than he ought to have done; one of the greatest Faults that a Mathematician can be charged with.

This Author reproaches Sir *Isaac* with having inferred the different Refrangibility of the solar Rays from the preceding Observations; whereas Sir *Isaac* declares in express Terms, that the Observation is not sufficient for that Purpose, because this strange Appearance of the Image may proceed from the Dispersion of the Rays as *Grimaldo* supposes; or from an Inequality of Refractions, not constant, but only casual, and therefore can have nothing deduced from it.

The more scrupulous this great Philosopher appears in his Reasoning, the more licentious does his Adversary seem in his Accusation. In order to remove the Dispersion of *Grimaldo*, and the fortuitous Inequality of the Refractions, he invented the following Experiment, which is as it were the Arbitrator and Judge of the Controversy.

He received the coloured Image of the Sun formed by the Prism, and cast upon the Wall upon the Face of another Prism, placed upright in such a manner, that the *Red* of the Image should fall upon the lower, and the *Violet* in the superior Part of this Face, and the other intermediate Colours should fall respectively in the intermediate Spaces betwixt the *Red* and the *Violet*.

If the first Prism, which was placed horizontally refracted the Rays upwards, this second placed upright must refract them sideways, either on the right or the left; so that if they were at first thrown almost directly upon the Wall opposite to the Window, they must now strike it obliquely, and with some Inclination. The Refraction then, which the Colours are to suffer

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fer in passing sideways through this second upright Prism, is the Thing which must determine the Question, either in Favour of Sir *Isaac Newton's* Supposition of the different Refrangibility, or for *Grimaldo's* Notion of the Dispersion of the Rays ; or lastly, must give the Preference to a fortuitous and casual Inequality of the Refractions, which cannot agree with any System at all.

For if the solar Image, formed by the first Prism, which refracted the Rays upwards received it's Colours and oblong Figure from a Dispersion or Dilatation of every Incident Ray a second Transverse and sideways Refraction, caused by the second Prism, must after the same manner shatter and dilate the Rays of this Image sideways, and render it of the same Oblongitude in Breadth, as it had before been in Length ; so that a new Image would be painted upon the Wall of the Chamber, which is behind the second Prism ; and this Image would be coloured differently from what it was before, and be changed from an oblong Figure, to one almost square.

Lastly, if the Colours and oblong Figure of the Image, formed by the first

Prism, were occasioned by a fortuitous and accidental Inequality of Refractions, who can tell what Variations Chance might have produced in the Combination of the second Prism, and in the new Refraction which that Prism gave to the Light?

But whatever Effect Chance might produce in this Case, it is certain it could never agree with what the *Newtonian* System aims at.

According to this System, if the colouring and oblong Figure of the Image formed by the first Prism were occasioned by the Separation of Rays differently coloured, and differently refrangible, a second Refraction, made sideways, can only incline this Image, and must leave it just the same as it was before with regard to it's Colours and oblong Figure.

How will it incline the Image, said the Marchioness? I do not understand the Reason of this.

You will soon understand it, answered I, when you reflect, that if the second Prism was removed, the Rays would all strike the Wall almost in a direct Line. Now if the second Prism refracts the *Violet* Rays, that is, turns them sideways and transversely
out

out of their Path, more than it does the *Red*, those must strike the Wall more obliquely than these, or in other Words, the *Violet* must fall at a greater Distance from the Prism than the *Red*.

The intermediate Colours too, between the *Red* and the *Violet*, will fall upon intermediate Places of the Wall. Thus the Image will appear inclined, and as it were leaning with it's *Violet* Extremity farther from the Prism than the *Red* is. These Effects must happen according to Sir *Isaac Newton's* System, and these in Reality do happen, as I myself have often had the Pleasure of seeing.

If after the second Prism there be placed a third and fourth, in order that the Image may be successively refracted sideways thro' them all ; those Rays, which were refracted more than the rest in the first Prism, will be more refracted too in the following Prisms. But the Image will not be dilated sideways, nor coloured differently from what it was at first.

Nature, said the Marchioness, has pronounced the grand Judgment, and of three Systems, that contended for it, the *Newtonian* has carried the golden Apple. I must

confess this Decision does not displease me ; for to say nothing of the accidental Inequality of Refractions which does not deserve the Prize, *Grimaldo's* Supposition, of the Shattering and Dilatation of every particular Ray, had something too perplexed and embarrassing in it. If you think the Judgment which Nature has pronounced in favour of our Philosopher, answered I, to be so just, that of his Adversary, whom I lately mentioned, will appear extremely capricious, who asserts, that Sir *Isaac Newton* has, by pleasing Experiments, confirmed the Observations of *Grimaldo*.

I am not so greatly surprized at this Adversary, replied the Marchioness, who does not appear to have any great Knowledge of the Matter, as at *Grimaldo* himself, who neglected to prove the Truth of his Dispersion of the Rays, by so easy and simple an Experiment as this, which requires nothing more than a second Prism after the first. One would imagine that it should have been very obvious to a Person bent upon making a System. Say rather answered I, to a Person long exercised in the Arts of Observation, for a Love of building Systems and making Experiments,

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are two Things that seldom go together : But it generally happens that the most simple Things are the most difficult, and consequently the longest before they are found out.

The Circulation of the Blood, for Example, appears to be a very easy Discovery, and one would imagine should have been very anciently made. When an Orifice is opened in the Arm, the Arteries swell from the Heart towards the Extremities of the Body, and the Veins on the contrary from the Extremities of the Body, towards the Heart ? This evidently shews that certain Vessels, that is, the Arteries, are designed to convey the Blood from the Heart to the extreme Parts, and other Vessels ; namely, the Veins, to carry it from the Extremities to the Heart. Besides, the Death of *Seneca* might have furnished the Ancients with a physical Experiment, as well as a moral Precept. It was impossible that all the Blood should be emitted through the opening of the Veins, unless those of the superior Parts had a Communication with those of the inferior, or in other Words, unless it circulated through the whole Body.

It appears then, that it was much easier for the Ancients to discover the Circulation of the Blood, who had so many Experiments ready prepared to their Hands, than for *Grimaldo* to find the Falshood of his Disperſion, becauſe his Experiments muſt muſt have been the Effect of his own Labour and Invention.

It is true, ſome Bigots for Antiquity pretend to find this Diſcovery in *Hippocrates*, ſo that according to them, all the Inventions of the Moderns, and all our Diſtempers were known to the Ancients. But this Notion is the ſame as if a *bellutellus* or ſome other zealous Admirer of *Petrarch* ſhould diſcover the *Newtonian* System of Opticks in theſe Verſes:

While the great Author of his Frame
expires,

The conſcious Sun withdraws his active
Fires ;

Pale ſickly Shades o'erſpread his languid
Ray,

And every beauteous Colour fades away.

The moſt ſimple Things are generally diſcovered the lateſt, and with the greateſt Difficulty. This

This Aphorism, said the Marchioness, is too well verified even in the *Toilette*, where an elegant, but simple Disposition of our Hair or our Patches, often costs great Trouble, and the utmost Anxiety of Mind.

According to this Principle, answered I, Sir *Isaac Newton*'s Experiments must have cost him an infinite deal of Labour. For if the preceding Experiment, to prove the different Refrangibility of the Rays, is at once simple, elegant and conclusive, all the others which he invented for the same Purpose are no less perfect, and yet appear so very obvious, that every one would imagine he himself might have as easily found them out.

How, said the Marchioness! Is not this Experiment sufficient to prove the different Refrangibility without seeking for any more?

Have I acted wrong in suffering myself to be too easily convinced? No, Madam, answered I, a Lady cannot err in this Point. But, Sir *Isaac Newton* himself does not desire you should assent to his System so soon. This Experiment, without Dispute, is sufficient to demonstrate the different Refrangibility, but not to satisfy a *Philosopher* re-

solved to try Nature a thousand Ways, and put her to a thousand Proofs, in order to establish his Belief on a sure Foundation.

You seem, said the Marchioness, to represent Nature as a Coquet, and Sir *Isaac Newton* as a jealous Lover, who never thinks he has Proof enough of the Fidelity of his Mistress.

This however, answered I, was the only Object of his Love. I am very sorry that I cannot shew you all the Experiments which he invented for this Purpose, in order to present you with the most finished and beautiful Piece that philosophical Jealousy ever composed. But the Parts I shall shew you will assist you to form an Idea of the Whole, just as the *Obelisks* and *Amphitheatres* discover the Grandeur of ancient *Rome*.

Let me intreat you, said the Marchioness, to make me a compleat *Newtonian*. I plainly see that by my Conversion, I shall acquire the Knowledge of Truth without losing that Pleasure which I found in being deceived.

In the dark Chamber which we have prepared for our Experiment, continued I, let a white Thread be extended horizontally against the Window, but at some little
Distance

Distance from it. Let two Rays of the Sun enter at two Holes made in the Window-Shutter, which, refracted by the two Prisms, may paint two coloured Images upon the opposite Wall. When this is done, we must recommend ourselves to the Genius which presides over *Opticks*, and then patiently wait till the half of this Thread be illuminated by the *red* Rays of one Image, and half of it by the *violet* Rays of the other. Let the Wall opposite to the Window be covered with a *black* Cloth, that the Colours, which would otherwise be reflected by the Wall, may not disturb the Experiment; for at present we want no other Colours but those of the Thread, which must be alone distinguished.

This Thread must be observed through a Prism, placed before the Eyes in such a Position, that all the Objects seen through it appear higher than they really are; the Thread too will appear to be transported higher by the Refraction, but because the *Violet* half should suffer a greater Refraction than the *Red*, it will be much more transposed than the *Red*, so that the Thread will appear divided into two Parts, the one illuminated with *Violet*, the other with
Red,

Red, and the *Red* will appear lower than the *Violet*.

This Experiment if we should exclude every other, is intirely agreeable in all it's Parts to the *Newtonian* System, if the *Violet* Part of the Thread be illuminated with *Indigo*, the Thread will appear less divided than at first, the *Indigo* half approaching nearer to the *Red* than the *Violet* did ; which must necessarily happen, because the Difference of Refrangibility between the *Indigo* Rays and the *Red*, is less than that between the *Red* and *Violet*.

If from *Indigo* this half be illuminated with *Blue*, the other half still remaining *Red*, the Thread will, for the same Reason as I before mentioned, appear less divided than at first, and still successively less, if it be illuminated with the other Colours in Order, *Green*, *Yellow*, and *Orange*, till at Length becoming *Red* like the other half, the Thread will no longer appear broken nor divided in two as at first, but whole and continued ; because now the Colours of each half have no Difference in their Refrangibility.

A like Experiment may be made with a Paper, the one half coloured with *Red*,
and

and the other *Blue* ; placed afterwards upon a black Cloth and looked at through a Prism, it will appear broken and divided into two Parts. A Paper illuminated with four Colours, (which I have myself seen demonstrated) that is *Red, Yellow, Green, and Blue*, ranged one after another in the Order I have named them, appeared through a Prism divided into four Pieces like the Steps of a Ladder.

The *Blue* is sometimes the highest of all and sometimes lowest, as the Position of the Prism requires. This Experiment, varied in as many Ways as the fruitful Imagination of *Paul Veronese* would vary the Subject of a Picture, always succeeded so well, as to have greatly confirmed this System, if it's Author had suffered it to need any Confirmation.

I must ingenuously confess, said the Marchioness, that though I have always regarded the *Mathematicians* with a singular Veneration, I do not yet understand what their Demonstrations are. However familiar they may at present be rendered, I do not comprehend them enough to find the Solution of a Problem among the Patch-boxes and Perfumes on my Toilette. I now begin

gin to fear that my Ignorance of the Deity I worshipped, greatly increased my Veneration for it.

Their Evidence causes so great a Noise in the World, that I was persuaded every Thing else, however well it might be proved, had only a small Degree of Probability when compared with these. At present I cannot conceive it possible, for any mathematical Demonstration to be more certain than Sir *Isaac Newton's* different Refrangibility, and yet this is a Thing merely physical. But you are to consider, Madam, that the Person who has treated upon this physical Subject, was the greatest *Mathematician* that ever appeared in the World. We may affirm then, replied the Marchioness, that as every Thing which *Midas* touched was transformed to Gold, so every Thing that Sir *Isaac Newton* handled became Demonstration.

If ever *Physics* could hope to vie in Certainty with *Geometry*, answered I, they might with some Reason expect it, when treated by Sir *Isaac Newton*, though there is a very great Difference in the Nature of their Proofs.

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Physicks can only consider a vast Number of Particulars, make Observations upon them, and thence deduce general Propositions: Whereas *Geometry*, by a more expeditious and certain Way, abstracts particular Cases, and founds it's Demonstrations upon Nature, and the Idea of the Thing itself, whereon it treats.

All that a *Mathematician* demonstrates to you concerning one Triangle will be true in all, be they of what Species they will; because he considers nothing but what is necessarily included in the Nature of a Figure terminated by three right Lines; and as this is found in all Triangles that can possibly be either made or imagined, his Proposition will hold true in all.

On the other Hand a *Naturalist* will tell you, that all Bodies here below gravitate, and if left to themselves descend; but he does not like the *Mathematician* deduce this Proposition from the Nature of Body (for that is unknown to him) but from a daily Observation that *Gold, Silver, Gems, Water, Air*, and a thousand other Bodies gravitate, and do it constantly by Day and Night, in Summer and Winter, fair and cloudy Weather; from whence it may reasonably be inferred
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by Induction, that every other Body gravitates at all Times, and in all Places.

But however reasonable this Method may seem, so great a Demand for Proofs implies a Want of Demonstration, just as a too great Attention to Dress argues some Defect of natural Beauty in a Face. Who can tell, but notwithstanding such a Multiplicity of Observations, some may question whether there be not a certain Body, with which we are yet unacquainted, that has no Gravitation? Or if there be not some Country in the unknown Tracts of the *Southern* Pole, where Bodies have not that Quality of Gravitation, which we discover them to be indued with in all the known World? Or lastly, whether in past Ages there may not have existed a certain Body that did not gravitate? You will grant, however, said the Marchioness, that where the Number of Observations is so great, as that from whence the Gravitation of Bodies, and the different Refrangibility of the Rays of Light are deduced, that Person must be inexcusable who doubts their Evidence, unless it was prescribed him by a Physician for his Health.

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If there are some, answered I, too excessive in their Doubts, there are many others too bold in their Assertions. All do not imitate the prudent and necessary Reserve of our judicious Philosopher: Some are contented with one single particular Case, from which they hastily deduce a general Conclusion, like those who form a Judgment of the Temper and general Character of a whole Nation, from the particular Humour of a single Person, whom they have seen perhaps once or twice at a Coffee-house. Sir *Isaac Newton's* Antagonist whom I lately mentioned, imagining he had overthrown the System, and principally the different Refrangibility, in Order to prove himself the Opponent of this great Author, even in the Method of philosophising, has put together a general System (hinted at by others, but not followed) formed upon particular Cases, which well examined are nothing but Consequences of that, which he imagined himself to have overthrown.

He supposes certain Grounds, and a Mixture of Light and Shade; and the different Combinations of these, are according to his Opinion, the Cause of different Colours.—

Can

Can a Combination of Light and Shade, interrupted the Marchioness, ever produce *Red* or *Yellow*? A Phænomenon must be very unfortunate, whose Explication depends on this System. Perhaps, answered I, smiling, those Phænomena which contradict general Laws, those Monsters of *Opticks*, if there are any such, are sent by Nature to this System for their Explication, and do not these fine Colours of yours too, deserve a little Punishment for all the Mischiefs they have caused? But see the unhappy Condition of the poor prismatic Colours, which certainly do not merit the Correction that yours do; and from hence you may form an Idea of the Value of this System.

It affirms, that when a Ray of the Sun is refracted by a Prism, these Colours are produced by Means of two Sorts of Images, the one formed by the Dispersion of the solar Rays, and the other by that of the Rays of Heaven, which are contiguous to those of the Sun. What, said the Marchioness, does this *Philosopher* attempt to bring this Dispersion again upon the Stage? Had he never seen the Experiment of the second upright Prism, which has for ever banished this Supposition from the Province of *Opticks*? Authors,

Authors, answered I, have their Eyes formed differently from those of other Men. The Sun is Light, and the Sky comparatively dark. This was sufficient to furnish the *Philosopher*, we are speaking of, with Abundance of Relations betwixt Light and Shade (the Veils, as he expresses it, formed by these two Images) from whence he draws an Explication of the Difference of Colours in a Prism. I fancy, said the Marchioness, this Explication will not be very simple; it appears to me sufficiently perplexed. Not to insist upon this and many other Difficulties which this System is chargeable with, we will confine ourselves to the following Objection, answered I.

If it be true that this Diversity of Colours depends on a Mixture of the Rays of these two Images of the Sun and Sky, and from their shadowing each other, it is clear that if there can be found a Method to prevent the celestial Rays from coming to the Prism, and consequently from being refracted and mixt with those of the Sun, the Colours will vanish with all that fine *Theory*, which arises from the Mixture of those two Sorts of Rays.

Now this may easily be effected, if before the Ray of the Sun (which enters at the Window of the dark Room) be refracted by the Prism, the Middle of the Ray be transmitted through another Hole made in a Table, or a Past-board placed at some Distance from the Window. In this Case, so far is the Prism from receiving the celestial Rays contiguous to those of the Sun, that it receives no Rays from the Sun himself, but what flow from his Disk, and is not at all affected by those which proceed from his Edge.

It is evident then, that if this System be true, the Colours of the Images in this Case could not appear, which is absolutely contrary to Experience, a Disgrace pretty familiar to this System.

You seem, said the Marchioness, to resemble *Bacchus* throwing down the Giants, who attempted to dethrone the Gods, in order to usurp their Places : The Spirit of Ambition appears no less strong in this Author, than in those presumptuous Sons of Earth.

You are to suppose, answered I, that an Author is often as strongly desirous of giving his Name to a new System, as a *French*

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How happy would they be, if like that *Chinese* Emperor, who burnt all the Books of History preceding his Reign, in Order to make his Name the first Epocha of it, they could destroy all preceding Systems, to make their own the Epocha of human Knowledge.

Besides, Sir *Isaac Newton's Theory* came from a Country too far beyond the *Alps*, to be favourably received among *Italians*.

It would be very surprizing, if a System produced in *England*, had not been treated with Aversion by some Persons, in a Country so near the Sun as ours.

I do not see, replied the Marchioness, why a System should meet with the worse Usage, for being a Native of *England*. For my Part, as much an *Italian* as I am, I do not believe that I should be prejudiced against a well grounded one, even if it had been produced in *Ireland* or *Nova Zembla*.

You are not to imagine yourself, answered I, to be ranked with the Generality of Mankind. A Sea, a River, or a Chain of Mountains, placed between some People and a certain Truth, are insuperable Objections

jections to their Reception of it. Perhaps as the *Romans* found a certain *Je ne scais quoi*, in the Stile of *Livy*, which discovered the *Paduan*; so our *Italians* find a *Je ne scais quoi*, in every Truth that comes from beyond the *Alps*, which does not agree with their Taste. These Gentlemen, said the Marchioness, must have a very distinguishing Judgment to discover such Differences as these; or it rather argues they have no Taste for Truth, who find any Thing foreign in the Proofs of a different Refrangibility. In this I may venture to affirm myself a better *Italian* than they, since the least Difference in this Case must turn to our Disadvantage.

You, Madam, said I, are a Citizen of the World, and your Senses formed for Truth, are Proof against the Objections of those who only appear to be zealous for it. You will find a new Demonstration of the different Refrangibilities, drawn from the Difference in the Focus of a Lens, through which the different Colours are viewed.

The Image of the Letters of a Book, formed by a convex Glass, illuminated by the *red* Rays of a Prism, appears distinct at a certain

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a certain Distance from the Glass: The Image of the same Letters, when illuminated by the *Blue* Rays is not distinct, but at a less Distance.

In the like Manner, the four Colours, *Red*, *Yellow*, *Green*, and *Blue*, of the Paper we before-mentioned, are not equally distinct when placed at an equal Distance from the Lens. The *Blue* is nearest, next follows the *Green*, afterwards the *Yellow*, and last of all the *Red*, whose Rays, being less refrangible than the rest, must be collected and united at a greater Distance from the Lens.

Might not some wise Caviller, said the Marchioness smiling, gravely object, that the Book which first received the *Red*, and afterwards the *Blue* Rays, was wrote in *English*; and that in Order to prove the different Refrangibility, it was necessary for it to be *Italian*? But after all, it is an infamous Thing to be so hardened against the Truth.

Are not these Experiments sufficiently decisive? And can there in any Country of the World be assigned a Cause, why the Image of one Colour should be nearer to a Lens than that of another, unless it be

the different Refraction which they suffer in passing through the Lens. Do not put yourself in a Passion, Madam, said I, the different Refrangibility will be true, notwithstanding these Objections. You may still safely believe it, as many other judicious Persons do, in Defiance of that obstinate War, which the Antagonist of our *Philosopher* declared against it.

The *Newtonian* System had the same Fortune, as that Field where *Hannibal* encamped when he besieged *Rome*, which did not sell at all the worse upon that Account: Or rather, you may look upon these Objections as the satyrical Verses, those miserable Invectives, which the Licentiousness and Malignity of the common Soldiers, mixt with the Acclamations and Glory of a *Roman* Triumph. The Beauty and Simplicity of this System did not deserve to pass unmolested by Envy and Censure, that Tax which Merit is bound to pay to the Publick.

A celebrated Minister *, at once capable of the sublimest Projects and the lowest Employments, and a whole College, joined

* Cardinal Richlieu.

their

their Forces against the Applauses paid to the *Cid*.

For a like Reason, *Moliere's Misanthrope* was recited to the same Auditory, that listened to the Sermons of *Cotin*. How often have the celebrated *Carracci* had the Mortification of seeing their fine Pieces sold in their Life Time by the Ell, (if I may use that Expression) which now are the Ornaments of the most select Galleries, and paid by the Admiration of Connoisseurs, better than by the Gold of the Rich!

It was necessary for the Honour of Sir *Isaac Newton's Theory*, that it should be attacked on all Sides, and that some should dispute the different Refrangibility of the Rays, while others wrangle about the Immutability of Colours, which is another of their Properties discovered by our penetrating Philosopher.

The Experiment, upon which this new Quality of Colours is principally founded, was renewed in *France* by Monsieur *Mariotte*, a Man exceedingly well versed in the Arts of Observation. This Experiment, in his Hands, produced an Effect contrary to what Sir *Isaac Newton* had given Reason to hope for.

Thus a System, the slow and considerate Offspring of Reasoning and Experience, was esteemed imaginary and vain; and a grave Philosopher, who spent his whole Life in the Study of Truth, passed for a Reveur, or an Impostor.

Did not the same Thing happen to poor *Cato*, said she, who notwithstanding the many Instances he had given of his Magnanimity, and generous Resolution not to survive the Liberty of his Country, was branded by some with the Infamy of having killed himself through Cowardice.

What is this you tell me, says the Marchioness, of an Experiment in *France*, contrary to that of Sir *Isaac Newton*. Is it possible that two Men equally attentive and accustomed to Observation, should need a third to decide a Matter of Fact? It is not surprising, that two People should reason differently upon the Circumstances of a Fact, according to their different Principles; as in the Case of a Person who shifted his Linen three Times a Day, one asserted that he must be extremely neat, and the other, that he was a very Sloven.

But to dispute and mutually to deny the Fact itself, I always thought reserved for silly Women and Enthusiasts. It

It is certainly, answered I, a great Reflection upon Philosophers, when we find them dissent in Matters like these, it at least demonstrates that one of them must have been inattentive in observing the Laws of Nature.

Those rational Horses so far superior to us Men, which *Gulliver* discovered in the Island of the *Houyhnnms*, the last Place where he arrived at in his allegorical Voyages, were extremely surprized to find such Contradictions among our *Philosophers*, that is, those of our Species, who take the most Pains to cultivate their Reason.

These happy Animals know not the Meaning of Uncertainty and Doubt in Matters of Fact.

The Dishonour that *Philosophers* receive upon this Account is very great even among us, and there are too many Examples of it.

Two famous Academies which have equally Truth for their End, and Emulation for their Companion and Guide, disputed upon a Fact by which is demonstrated the Refraction which Light suffers in passing from a *Vacuum* into Air. That Academy which maintained the Refraction, was at Length

victorious; and it was necessary that even this Truth should be contested, in Order to be admitted. Some from Experience will tell you, that in breathing the Air passes from the Lungs to the Heart; while others alledge the same Experiment to prove that it does not. Many discover certain little Machines and Organizations in the Glands of a Body, which others affirm cannot be seen.

Fancy and Prepossession have the same Influence here as in all other Things, and make us think we discover in Objects without us, what runs strongest in our own Mind.

Thus a few irregular Strokes will appear to the Eyes of a Painter, the Contour of a Leg or a Face, Windmills become Giants to Don Quixote, and Fires and Beeches seem transformed to a fine Lady in the Eyes of a Lover.

An Observer must not search into Experiments, in Order to find his own Opinions there; like that Person who looked for his Pedigree in *Homer*, because both the one and the other will every where meet their own Imaginations.

Natural

Natural Philosophy, like *Poetry*, requires a Man formed expressly for it, a *Malpighi*, a *Reanmur*, a *Boyle*, not moved by Authority, seduced by Fancy, nor terrified by Difficulties, an ideal Man (if we will believe a celebrated Writer) dexterous, active, and curious, as the *French* and *English*, and reserved, cautious, and circumspect, as the *Italians* and *Spaniards*.

Why not the Patience of some other Nation, said the Marchioness, instead of the Caution of ours, which is too like Diffidence to redound greatly to our Honour.

This Author, answered I, considers only the good Qualities of different Nations. But you would be better pleased, perhaps, if the Part we contribute to the Formation of a perfect Philosopher, were the religious Attention of our passionate Lovers.

I am acquainted with one of these, said the Marchioness, who would be a *Newtonian*, if Philosophy was his Mistress.

This Attention, answered I, might carry these Gentlemen to a great Height of Superstition, as it does a *Naturalist*; who prescribes it as a Rule of Art, whenever an Experiment is made, to mark exactly the Country, Hour of the Day in which it was effected,

what Wind blew at that Time, the Degree of Heat, and the Drought of the Air, with many other Circumstances of this Nature, which in some Cases may be proper and even absolutely necessary. But in others, I really do not see of what Service they are; for in looking upon a Paper of two Colours with a Prism, it is of no Sort of Importance whether the Wind blows East or West, whether the Time of the Year be Autumn or Spring, the seventh or twentieth Day of the Month.

These circumstantial *Naturalists* resemble an *Antiquarian*, who should copy the Cornice of an Inscription with as much Exactness as the Inscription itself.

Physic, replied the Marchioness, has almost divested itself of the Prejudice of observing certain Seasons of the Moon, as a proper Time to apply it's Medicines; and perhaps *Natural Philosophy* has assumed it in her stead, that these superstitious Notions may not be destroyed, but there may always be pretty near an equal Dose of them in the World.

It must be confessed, however, answered I, that there may always be hoped some good Effects from this diligent Disposition, even though it be carried to such a Degree

as

as to become ridiculous : But we can never expect any good from Negligence. You will see an evident Proof of this, in that celebrated Experiment of Sir *Isaac Newton*, before which all the ancient Idols of *Optics* fall to the Ground ; those imaginary Systems which supposed Colour might be changed by Refraction, Reflection, the Confinity to Shadow ; and in short, that Colour is nothing but a certain Modification, as they express it of Light, which may easily be changed by these Circumstances.

But Sir *Isaac Newton* has shewed the Falshood of this Opinion, and demonstrated that a Ray (for Example, *Red*,) well separated from all the rest, will constantly keep it's Colour in spite of any Refraction or Reflection it is made to suffer, or any other Method that the fruitful Invention of a Naturalist can contrive to torment it.

The same Constancy will hold good in all the other Colours, if they are well separated. The grand Experiment which furnishes us with these agreeable and surprising Truths, is this which follows.

The Image of the Sun formed by the Conjunction of a Prism and Lens, is re-

ceived upon a Paper. By this Conjunction the Colours are much more unmixed and better separated than they would otherways be. Having thus made a more perfect Separation, the Rays of different Colours must pass successively through a Hole in the Paper, that they may be refracted by a second Prism, in order to prove whether this new Refraction can produce any new Colour.

If it should, we must confess that Colour is nothing more than a certain Modification which the Light acquires in passing through the Prism; and then *Philosophers* may set their Imaginations to work, in order to find out what Motions, Figures, and the like, are necessary to produce this Modification.

But on the other Hand if the Ray constantly preserves it's own Colour without the least Alteration, we must agree that Refraction has no Share in the Production of Colours, and abandon the ancient System of Modification; and all it's ingenious delusive Dreams will vanish at the opening Morn of the *Newtonian* Truth.

Now the Experiment we are upon demonstrates that a homogeneous Ray *Red, Yellow, Blue,* or of any other primary Colour,

Colour, is not in the least altered by a new Refraction, nor even by a great Number of Refractions which it is successively made to suffer.—It is not changed either in it's Colour or Degree of Refrangibility which remains constantly the same. Thus if two Rays, one *Red*, and the other *Violet*, be made to fall one after another upon the second Prism, with the same Incidence (that is, if both the Rays coming from the same Point, fall likewise upon the same Point of the Prism;) if the Rays, I say, fall upon the second Prism in this Manner, the *Violet*, after the second Reflection, will strike the opposite Wall in a Situation higher than the *Red*, and the intermediate Colours in intermediate Situations; those which had suffered the greater Refraction in the first Prism, suffering the greater in the second likewise; all these Colours will paint upon a white Paper directly opposite to them, a little Circle perfectly round, and not oblong like the Image made by the first Prism, and this Circle will be of the same Colour as the Rays without any Addition or Mixture.

I beseech you to stop and take Breath, said the Marchioness, you were engaged in

such a long Period, that I began to think you would never get to the End of it. I should be sorry, Madam, answered I, if the Length of the Period has rendered me obscure, and made you lose so fine an Experiment.

No, no, said the Marchioness, I understand it very well. Does not all your Meanings amount to this, that homogeneal Rays of Light are immutable, both with respect to Colour and Degree of Refrangibility? I am extremely rejoiced, said I, to find I may be as prolix in my Periods as I please, without Apprehension of Obscurity, and may employ one as long as those of the *Azolian* Dialoguists, to tell you that this is the Experiment which Mr. *Marriotte* endeavoured to make, and by some Misfortune found, that after the second Refraction certain new Colours were united to the *Red* and *Blue*.

I know not how this happened, but probably it was from some Defect in the Prism which he employed.

The ill Success of this Experiment, would have done the Immutability of Colour no small Injury in the learned World beyond Sea, if it had not been repeated in *England* before some learned *Frenchmen*, the Motive of

of whose Voyage was purely Philosophical.

This Repetition of the Experiment clearly demonstrated, that Mr. *Marriotte*, though otherways an accurate Observer, has failed in some of the Circumstances necessary to bring it to good Effect. Thus were these two Nations (more divided by their different Ways of thinking, than by a little Arm of the Sea) reconciled upon this Point.

This Law of Nature, common to all Nations acquainted with Light, met with a less favourable Reception in *Italy*, than in any other. The most obstinate Antagonists of the *Newtonian Theory* have risen among us; there seems to be some Fatality in this, that a Nation, which the *Italians* once found so difficult to subdue by Force, should in it's Turn find us the most difficult to be subdued by Reason.

In order to contribute my Share to the Establishment of this Law even among us, I caused the same Experiment to be repeated at a Place in *Italy*, celebrated for the learned Men it has always produced, and Neuter enough not to be suspected of Partiality.

No Minister of State, said the Marchioness, could act more politically in the Choice of a proper Place for the holding a Congress. Within a very little answered I, all my Politics would have signified nothing; for though we made use of Sir *Isaac Newton's* own Method in separating the Colours, and the Chamber was extremely dark, yet a certain Light of a bluish Cast always mixt itself with the Colours refracted by the second Prism. 'Tis true, this Light was irregular and inconstant; but however it was sufficient to serve for an Excuse to the Incredulous.

This Appearance gave us a real Inquietude, and we would never have slept in Peace, if we had not after much Study found out the Cause. We observed that the Borders of the coloured Image were not so well terminated as they ought to have been, provided the Prism, by which it was coloured, had been good.

We discovered a Light round the Edges, of the same Nature with that which was observed to be mixt with the Colours refracted the second Time, and we perceived that several Streaks of this Light crossed the Image from one End to the other.

From

From all these Circumstances it appeared there must be several Irregularities in the Prism, as Bubbles of Air inclosed in the Glass, Unevenness in the Surface, and other Things of the like Nature, which were probably the Reason why the Light was irregularly refracted; and by this Means rendered it impossible for the Colours upon the Image to be perfectly separated.

Various and repeated Experiments made it evident, that the Fault of this apparent Alteration of Colours, which we observed in the Image, must be imputed entirely to that irregular Light which we had before suspected to be the Cause; if we may call that an Alteration which was nothing but the Addition of one Colour to another.

I congratulate you, interrupted the Marchioness, that after such a Discovery, nothing will hereafter disturb the Tranquillity of your Sleep.

Heaven preserve me, answered I, from that cold tedious Tranquillity, which is however the Object of our Desires. 'Tis in Philosophy as in Love, and in all other human Affairs, where the Accomplishment of one Desire often gives Birth to another.

When

When we had discovered the Cause of this Defect in our Experiments, our next Business was to find some Remedy for it. The Difficulty of acquiring it was a new Motive for our Labour and Inquietude.

Our Prisms in *Italy* are of no other Use than to amuse Children, or hang up as a fine Shew in some Window in the Country, and not for the Service of Philosophers, who are often too exact for Artificers, and require a greater Accuracy than is in the Power of Art to bestow.

We resolved to write to *England*, which has it's *Fawknars* for Lapidaries, and it's *Grahams* for Clock-making, where, in short, every Thing seems to be contrived for the Service of the most curious and importunate Naturalists, if Fortune and our good Genius had not unexpectedly furnished us with some which were just arrived from that Country.

These we esteemed as sacred, as the *Romans* did the Ancile or Shield which fell from Heaven in the Reign of *Numa*, and we could have wished for a *Mamurius* to make us as many Copies of these, as he had formerly done of that.

With

With one of these Prisms we renewed the Experiment, and the coloured Image painted by it emerged so beautiful, so well terminated and so lively, that the other seemed no more, when compared to this, than a rough Draught to a finished Picture.

The Colours refracted by a second Prism remained so immutable, that neither the most penetrating Eye, nor even the *Zoilus* of the *Newtonian* System, would have discovered the least Alteration.

Perhaps, said the Marchioness, Nature has reserved the Merit of demonstrating Truth to the *English* Prisms; that is, to those by whose Means she at first discovered herself. It would be a very curious Phenomenon, answered I, to observe such a Partiality in Nature, as for her to prefer such a Prism made in *London*, to one produced in *Murano*.

But the Truth is, that if we consult her as we ought, she always answers the same, whether the Prism be *English* or *Italian*, provided it be good and well wrought, and the Chamber where the Experiment is made extremely dark.

If all these Circumstances are rightly prepared, the Colours, though refracted three

or

or four times, will remain unchangeable, neither more nor less with regard either to Colour or Figure, than an Object exposed to a homogeneal Light, and viewed through a Prism.

The Variety of Colours, the Change of Figure, and the Confusion discovered in Objects looked upon in this manner, proceeds from nothing but their reflecting more or less, all sorts of Rays, which, being afterwards differently refracted, produce all these Irregularities.

If upon a Circle of Paper there fall at the same Time the *Red* of one Image, and the *Blue* of another, so that the *Purple* Colour composed of both these may appear, it will, when examined through a Prism, seem divided into two separate Circles, the one *Red*, and the other *Blue*; and the Reason of this Appearance is the unequal Refraction of these two Colours.

If the *Yellow* and *Green* of two other Images should fall at the same Time upon the Paper, so that it would be illuminated with four Colours at once, it will appear oblong, and divided by Refraction into as many Circles as there are Colours, and these Circles will seem placed upon one another.

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I know you are going to add, said the Marchioness, interrupting me, that if this Paper be exposed to the Light of the Sun, who contains every sort of Ray in himself, it will appear of a Figure still more oblong, and painted with all the Colours of the Rainbow ; whereas, if it be illuminated by only one homogeneal Light, it will alter neither it's Figure nor Colour when observed through a Prism.

You must forgive the Weakness of human Nature, Madam, answered I, if we generally finish the Sentence we have begun.

It was reserved for Sir *Isaac Newton* and you, to understand Nature by half a Word, and find out *Natural Philosophy*, notwithstanding it's Uncertainty.

It is superfluous to tell you, that Flies and other little Objects, placed in an homogeneal Light, appear very distinctly to the Eye with a Prism ; and the very smallest *Elzevier* Print may be read without any Difficulty ; but the same Things would not have this Effect when placed in the heterogeneous Light of the Sun, because of the Confusion and Quantities of Colours that arise.

In this Case I abandon the Prism to the Disposal of Poetry, to make use of it in Comparisons which do it no great Honour.

That celebrated Author, whose fine Ode you so much admired, compares it to false Eloquence which obscures the Face of Truth, lavishes it's Ornaments without Distinction, and diffuses it's glaring Colour over every Thing.

It is certain that the Poet in this Comparison means that Prism, which transmits the Rays of every Sort. And when it transmits only the homogeneous Rays, said the Marchioness, may we not compare it to true Eloquence and true Wit? For as it shews us the Objects removed out of their Place without any Alteration, so true Wit often surprizes us only by varying common Subjects in a new Manner.

You are so well acquainted with the Prism, answered I, that you may safely compare it with your own Wit. But I know not what Comparison you will find for the Immutability of Colours, unless you seek for it perhaps in your own Heart; and then knowing that Reflection has no more Influence on that Immutability than Refraction has, you will be better acquainted with it than you at present are. If

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If the Colours, with which Bodies are variegated and painted, were only a Modification, which the Rays of Light acquire by being reflected from their various Surfaces, as was once believed; a Body, which appears *Red* in the Light of the Sun, would still remain *Red* when placed in any other Colour of the painted Image: For Instance *Blue*, because it could modify this *blue* Colour refracted and modified already by the Prism, as well as it does the Light which comes directly from the Sun.

But Sir *Isaac Newton* has proved by Experiments, that every Body placed in homogeneous Rays, is of the same Colour as the Rays themselves; without allowing however, the Supposition that Bodies by Reflection modify the Light in such a Manner, as to make it receive this or that particular Colour. Thus all *white, red, yellow, blue, green* Bodies, as *Paper, Scarlet, Gold, Ultramarine* and *Grass*, in *red* Rays, appear totally *Red*; in *green* Rays totally *Green*, in *blue* totally *Blue*, and so of the rest.

The only Difference consists in this, that all these various Bodies placed in the same homogeneous Light are not all equally lumi-

nous; but every Body appears the most lively when placed in a Light of it's own Colour, except Paper, and all other white Bodies, which equally receive any Colour, and may be regarded as the *Cameleon* and *Proteus* of Optics.

Would this Diamond then, interrupted the Marchioness, if placed in the Rays of our coloured Image, take indifferently any Colour, and at one Time be transformed to a Ruby; at another to a Topaz, an Emerald, or a Sapphire? So much the more, answered I, as it would dart only one unmixed Colour, and all the varying Splendors, with which it sparkles in the direct Light of the Sun, would vanish in this homogeneous Light.

It is very pleasant to observe how the fine Dust or Atoms in the Air change Colour as they pass from one Ray to another, just as a River varies it's Colour, according to the various Qualities of it's Bottom.

Other Bodies, as I before-mentioned, are not equally lively when placed in different coloured Lights. The Varnish for Instance, with which *Martino*, the Emulator of the *Chinese* Art, makes so many fine Curiosities, is extremely luminous in the

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the *Red* Light, less in the *Green*, and still fainter in the *Blue*.

On the contrary, the *Lapis Lazuli*, which has the Honour to serve for a Repository to your Snuff, is extremely lively in the *Blue*, less so in the *Green*, still fainter in the *Yellow*, and almost dark in the *Red*.

The same Inequality holds good in Bodies seen by a transmitted Light, as is proved by Glasses of different Colours; so that every Body reflects or transmits, in great Abundance, those Rays which are of it's own Colour, and reflects or transmits the other Rays, in Proportion as they are nearer or farther off it's own Colour in the Order of Refrangibility.

It follows from hence, said the Marchioness, that no Colour, even that seems the most perfect, can be absolutely unmixed.

And perhaps it will never be in the Power of Art, to dye a Silk in such a Manner, as for it to reflect only one Sort of Rays. It would be more difficult, answered I, to sort the various Colours together, and flatter our Sight by the Concords of Harmony, if they were all homogeneous and unmixed. In this Case all the Delicacy of Nature would be requisite, to find out the

innumerable intermediate Shades betwixt any two Colours. But now, as every Colour is more or less blended with some other, we are by that Means furnished with a much more easy and expeditious Way. Hence it is, that the Gradation from one Shade to another (though perhaps there may be several intermediate ones wanting) does not appear defective to our Eye, which discovers in each the same Basis of all the Colours that softens them, and serves for a Support to the Harmony.

There would arise other Inconveniencies besides these, if coloured Mediums did not transmit every Sort of Ray; for this would aggravate a Distemper bad enough in itself, which infects and tinges the whole Body, and the Eye itself with an unpleasing *Yellow*. Persons under such Circumstances as these, when it is very improper to pay Visits to Ladies, would become absolutely blind, unless to yellow Objects, and could see no Faces but of those who are troubled with the same Disorder.

So that, added she, a perfectly complaisant Lover, if his Mistress should happen to be ill of this Distemper, must clothe himself in Yellow, (a Colour which though

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regarded with great Veneration in *China*, is not looked upon as a good Omen for Lovers among us) and perhaps get the Jaundice in Order to be seen by his Charmer, and give her a Proof of his Affection.

So perfect a Lover, answered I, would not be an improper Person to prove this Immutability of Colours, if we had no more Proofs to demonstrate it than what you have already seen. What remained to be shewn was, whether the Confines of Shadow, with which the Light is bounded, are capable of making any Alteration in the Colours? This would have been fine Sport for those *Naturalists* who lay hold on every Thing, in Order to build a System. Our *Philosopher* put the Colours to the Test of this new Experiment, and found nothing wanting in their Constancy, which maintains it's Ground, even when it happens that Rays of different Colours cross and intersect each other; it appears in short, to defy every Thing judged capable of bringing any Alteration upon them.

We must turn to our Romances, replied the Marchioness, to find a Constancy equal to that of your Colours. Their Heroines, whose Perseverance nothing can stagger,

how little do they resemble the *Ephesian* Matron.

The Constancy of these Colours must certainly appear very surprising to Ladies, answered I. I do not doubt but the greater Part of them would much sooner admit the System of *Lucretius*, who without so many Experiments affirmed, not only that they are mutable, but that any one Colour may be changed into all the rest.



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ENTERTAINMENT V.

*A Continuation of the Exposition of
NEWTON's Optics.*

HE Marchioness was scarcely got out of Bed next Morning, when, contrary to the Custom of the Fair, she sent for me into her Dressing-room ; but she knew too well her Charms received additional Graces from that agreeable Dishabille in which midling Beauties are so fearful of being surprized.

Indeed, Sir, cried she, as she saw me come towards her, this Philosophy of yours begins to grow a very serious Affair.

Never did I rest so ill as last Night, whether it was occasioned by *Physics* or not I wont pretend to say ; but this I will venture to affirm, that Philosophy and Wakefulness are inseparable Companions.

In my broken Dreams, I fancied myself transported into the Land of *Optics*, where all was Prisms, Lenses, Rays, vari-

ously refracted, coloured Images, and I know not what.

In short, all the Experiments and all the Apparatus of *Natural Philosophy*, which you have been describing to me, succeeded each other in my Imagination, like Visions and Phantoms.

However amusing all this may be in itself, I could never have believed that it would have so strongly possessed me, at a Time when Peoples Thoughts do not commonly turn upon Philosophy.

Why, to say Truth, Madam, replied I, it was rather a more proper Time to think of the Philosopher.—You need not doubt, answered she, but he was remembered : I assure you, he has no Reason to complain.

Oh ! then, returned I, there is no great Harm done. Pray recal this Dream, Madam, as often as you can, that you and your Philosopher may be quits.

How was it possible, continued she smiling, that while I was thinking of these curious Experiments, I could neglect to admire the Sagacity and Genius of the Philosopher who invented them, and to revere the Man to whom Nature itself seems to have pointed out the Way of arriving at a thorough Knowledge of her? Lord,

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Lord, Madam, answered I, you consider the Thing too seriously, and take it in a different Way from what I meant it; for in this Case I could dispense with your Reverence for the Philosopher, upon Condition that you will grant some of your Esteem to the Expounder of the *Theory*.

How do you mean, take the Thing too seriously, said she? We are here upon an Enquiry whether Colour be or be not liable to Change, and whether Rays be diversly refrangible; we are establishing and refuting Systems; in short, we seem to have laid aside the Search of Truth, and you cry that I consider the Thing too seriously?

But these same Systems, and this same Truth, however solemn they may sound to the Ear, should never break our Rest nor cloud our Dreams, a fine Reputation truly you would acquire me, if it were known, that I had so filled your Head with Prisms and Lenses, that they interrupt your Sleep, and encroach upon your Dreams.

These Sorts of Things should be treated as Love is by those who try to turn the Passion to Advantage; they are no Dupes to it, nor ever admits so much Tenderness as to destroy their Health, but

just enough to give them an Opportunity of passing two or three Hours agreeably every Day in their Mistresses Company.

You give me Lessons of Philosophy and Love both at once, replied the Marchioness; but do not you know, that People in their first Love are little attentive to the Counsels of Reason; the Heart is inflamed, the Senses are blinded, and they suffer themselves to be transported beyond the Bounds of Prudence and Repose; thus has it happened to me with regard to Philosophy.

I had scarce got a Glimpse of it's dazzling Beauty, e're I ceased to be Mistress of myself; nay, my Eagerness has hurried me forward to search for the Means of confirming Sir *Isaac's Theory*; judge then of the Violence of my Passion.

Let us see, Madam, what it will produce; for it is to strong Passions that we have always been indebted to for the most noble Performances: The *Iliad*, the *Æneid*, the Poems of *Dante*, and of *Milton*, were begun in the Fervour of their Youth, and the Vigour of their Passions. To these we may join (at least if we may judge by the Esteem that their Countrymen have of them) the *Lusiade* of *Camoens*, undertaken during

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during the Time of those dreadful Revolutions in *Portugal*, and while the *Portugueze* were engaged in their *American* Conquests; and the *Araucana* of the *Spaniards*, in which the Poet himself is the Hero of the Piece. Something, Madam, greater perhaps than these may be the Product of your 'last Night's interrupted Slumbers.

I am afraid, answered she, that it will amount to very little.

I was thinking, that if Light is composed of Rays of different Colours, which, blended together, produce white; we ought to examine whether these Colours, after being separated by the Prism, might not be mixt together again. I for a long Time considered, but with little Success, in what manner this could be effected.

Sir *Iaac Newton* himself, said I, has delivered you from this Trouble, for that Method of confirming his System which you mention is so good, or rather so evident and immediate a Consequence of Order, that he has made several Experiments to that Purpose. I am now going to shew you one of the most celebrated, and at the same Time the most simple to which this great Philosopher was conducted by that Spirit

of Order, which you possess in common with him.

The Image of the Sun made by a Prism in the dark Chamber, is received upon the Convex Lens, that the coloured Ray, which at going out of the Prism diverged, may by the Lens be made to converge and unite, and by this Means be again blended together.

I am quite ashamed both of my Stupidity and myself, interrupted the Marchioness. I had all the Materials necessary for the Execution of my Idea ready prepared to my Hand; they only wanted putting together, and I had not the Sense to do it.

You were greatly in the Right, to be unwilling that a Person should hear the Voice of Philosophy who is incapable of making it an Answer.

I might rather, answered I, apply to you that famous Saying of Antiquity, would to God that such as you are, you were one of us; you will find in *Optics* themselves some Consolation for what you call Stupidity.

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cave Glafs put together would make a Telescope ; and though they had the Materials every Day at Hand, were at laſt indebted to mere Chance for this uſeful Inſtrument.

It was a greater Diſgrace to Mankind not to diſcover it before, than Honour to them that they found it at laſt.

So that this uſeful and fine Invention is of the Number of thoſe, which are ſtanding Monuments of the Weakneſs of human Nature.

You comfort me, replied the Marchioneſs, at the Expence of Mankind. — But to return to our Subject.

I ſuppoſe that Point beyond the Lens, where the coloured Rays are united will appear totally white.

The Rays, answered I, have no ſooner paſſed through the Lens, but they begin to mix and efface each other ; and they loſe the fine harmonious Proportion eſta- bliſhed betwixt them in the Spaces of the coloured Image, the Original of the Muſick of the Eyes.

When they are all confined at Length, and incorporated together in the Focus of the Lens, they form a little circular Image

totally white, a Republick (if I may use the Expression) of Colours where they are all equally tempered together. The *Red* can no longer display it's lively Flame, the *Green* boasts no more the smiling Livery of the Spring, nor the *Blue* the Lucid Robe of Heaven, but all blended together, restore the Whiteness of the Sun, from whence they come; in such a Manner however, that as they recede from the Focus, they again renew their Splendor and Colour, but in a contrary Order, and the ravished Eye again wanders from one Pleasure to another.

You will easily understand how they come to be inverted, if you remember the two Sticks crossed together, mentioned by *Des Cartes*, which you once believed to have a greater Efficacy in explaining the Phænomena of *Optics*, than they really have.

The Appearance that the Colours again make beyond the Place where they were blended, demonstrates that the Rays lose neither their Colour nor Quality, as some might perhaps believe, but that the Whiteness which appears in the Focus of the Lens, is produced only by their Mixture.

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I now understand, said she, what you meant yesterday by saying, that the Immutability of Colours still remains even when Rays of a different Colour intersect and cross each other, or if it were otherways we should not see the Prismatick Colours re-appear beyond the Place where the Rays united.

This is the very Experiment, answered I, upon which the Immutability of Colours was grounded; and all the Experiments of Sir *Isaac Newton* have this peculiar and admirable Quality, that each single one is not contented with demonstrating only one Thing, as is the Case of most others, but demonstrates many more at the same Time.

This arises from the close Union, and almost geometrical Connexion which the Properties of Light have between themselves.

Sir *Isaac Newton*'s Experiment, said the Marchioness, seems to resemble the Battles of the Ancients, which often gained the Victor a great Number of Provinces by one Action. And those of most other Philosophers, answered I, the Battles of the Moderns, the most noisy Preparations, the most consummate Contrivance, and the Blood of Millions, amount to no more

than the taking a Place, which perhaps might have surrendered in two Months by a Treaty.

But to return to your Experiment. I call it your's, because though you did not invent it, you saw the Necessity there was for it's Invention, in Order to compleat the System. Our Philosopher never quitted it till he had varied it a thousand Ways.

It was necessary to prevent some one of the coloured Rays from passing through the Lens, in Order to see whether the Whiteness of the little circular Image would by that Means be changed.

This Sir *Isaac Newton* did, and intercepted the Passage sometimes of one Colour and sometimes of another; and the Whiteness ceased, and degenerated into that Colour which arises from the Composition of those Colours which were not intercepted, but suffered to pass through the Lens.

The Want of any Colour in the circular Image, which is not suffered to pass, will be very agreeably discovered by looking through a Prism, which resolves the Image into it's component Colours, by giving them a different Refraction.

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If all the Rays be transmitted through the Lens, the Image will be white ; but viewed through a Prism, it will appear of all Colours like the Rainbow : If any Ray be intercepted, this by the Prism was discovered to be wanting in the Image, till at last suffering only one Colour to pass through the Lens, this one Colour too was seen by the Prism.

If all the Colours were successively intercepted by the Teeth of a Comb made to pass very swiftly over the Lens, the circular Image would remain white, and the different Colours not be distinguished, by reason of the quick Impression which they all successively make upon the Eye.

You may perhaps have observed, that when a lighted Torch is moved nimbly round in a Circle, the whole Circle, which it forms in the Air, appears on Fire ; and the Reason of this is, because the Sensation (which in the several Places of that Circle it raises in the Eye) remains impressed till the Torch returns again to the same Place.

In the same Manner, when the Colours follow one another with an extreme Rapidity, the Impression of each of them remains

mains in the Eye, till a Revolution of all the Colours be compleated.

The Impressions therefore of all the successive Colours, are at once in the same Part of the Eye, and jointly excite the Sensation of Whiteness there.

The same was afterwards proved by a Wheel, whose Circle, painted with the several Colours of the Prism, appeared white when turned very rapidly round itself.

I must confess, said the Marchioness, that even if I could have found the Experiment I thought for, I should never have been able to diversify it so many different Ways, though the Inconstancy, which you Gentlemen lay to our Charge, might perhaps have given me no small Assistance.

This Inconstancy, answered I, which perhaps is not so great a Defect as some believe, was not wanting in *Sir Isaac Newton*. With the most fertile and almost poetical Imagination, he continually varied his Experiments, and invented new ones, which, though different from each other, all concurred to prove the same Thing. They seem to rise under his Hands, as the Poets make Flowers spring under the Feet of their Beauties. The

The coloured Image formed by the Prism becomes white when viewed through another Prism, placed in such a Manner as to contract the Image and mingle the Colours. I have observed the same Phænomen in the Rainbow, which is the Effect of a Separation of the solar Rays, in the Drops of Rain opposite to the Sun.

It appears white when viewed through the Prism, turned in such a Manner, as to contract it and blend the Colours together.

Those who live near the Cataracts of Rivers, see a Rainbow every Day, when the Sky is clear, formed by the Sun, in the Spry of the Waters dashed against the Rocks, making People have the Opportunity of seeing this Experiment much oftner than we can.

I would if possible, replied the Marchioness, have nothing to envy others. Though we have no Cataracts a Fountain will imitate the Rain, present us with the Colours of the Rainbow, and we may make our Observations at Pleasure. We will call this Fountain if you think proper, *The Fountain of Opticks.*

Till your Garden furnishes you with Proofs of the *Newtonian* System, answered
I, as

I, as the Gallery did with Objections against the *Cartesian*, you may return to the dark Room, there you will see that the Whiteness of a Paper, placed over-against the coloured Image of the Sun, does not suffer any Alteration, if it be placed in such a Manner as to partake equally of all the Colours: Whereas, if it approaches nearer to one than another, it's Whiteness will be tinged with that Colour which is next it. Is it possible for Truth to descend from Heaven with a more shining Train of Proofs?

I was very enterprizing, said the Marchioness, to hazard my Thoughts upon what cost Sir *Isaac Newton* so much Study. How is it possible I could ever have found out the least of these Experiments, as easy and simple as they now appear? But in Exchange, answered I, you could easily invent Things that perhaps would have puzzled the Philosopher. It is much more proper for you to know in what Proportion to mix Hope and Fear, Smiles and Frowns to prevent a Lover's Passion from growing languid, than to be exactly acquainted, what Quantity of different coloured Powders is necessary to be mixt together to form a White.

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This is another Experiment which our Philosopher tried, that there might be nothing wanting to confirm his System. It is true, the White which arises from this Composition is dusky, grey, and obscure, like the Colour of Ashes: And the Reason is, because the Colours of these Powders are too imperfect and faint, compared with those of the Prism, to make a lively clear White.

However, if this Mixture be exposed to the Sun, in Order to encrease the Force of the Light, that dusky obscure White will become bright and clear, though it will never equal the Strength of the Paper exposed to the same Light.

For this Reason in coloured Prints, one of the finest Inventions of our Time, which with only three Colours, perfectly imitate all the Variety of Painting, the Paper is left uncovered for strong Clears and Whites.

Water thickened with Soap, and agitated so as to raise a Froth, is more proper to demonstrate that a Composition of Colours produces White. After the Froth is a little settled, there will appear upon the Surfaces of the Bubbles, of which it is composed, different Colours, which, when
viewed

viewed at a Distance, cannot be distinguished from each other, and the whole Froth will appear perfectly white. This Experiment has, besides it's being an agreeable one, this farther Advantage that it is very easy to make.

Philosophy, says the Marchioness, from what I can discover of it is like a Game of Chess, which upon any other Occasion, I should make no Scruple to call an ingenious Pretext to waste Time. The very least Piece in the one, and the least Experiment in the other, is often of the highest Importance. A Pawn in the Hand of a skillful Player may give Check Mate, and a little Froth will furnish Sir *Isaac Newton* with a whole Magazine of Observations and Discoveries. Half the World that preceded him, had the same Bubbles and Froth before their Eyes, without so much as seeing them. The Ancients themselves would a thousand Times have seen and neglected them.

The Eyes of the Ancients, answered I, were much better able to judge of the Elegance of a Statue or a Temple, than the Importance of an Experiment. *Seneca* was acquainted with a Sort of Prism, which receiving

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ceiving the Light of the Sun on one Side, displayed to the Eye the Colours of the Rainbow.

All the Explication he gives this Phænomenon is, that there is really no Colour, but only an Appearance of a false Colour like that of a Dove, which appears and disappears according to the Motion of the Eye and the Change of the Situation.

This fine Explication sufficiently shews how very little the Ancients studied Nature and pursued her Steps; for if *Seneca* had taken the least Trouble to examine his Prism, he must have seen the Difference between the Colours produced by that and those on the Neck of a Dove.

A particular Sort of a Microscope known to this Philosopher, and which perhaps the ancient Artificers made Use of in the curious engraving of their *Intaglia's* and *Cameo's* (the Enigma and Admiration of our Time.) This Microscope, I say, composed of a Ball of Glass filled with Water, had no better Fortune in his Hands than the Prism. He ascribed the magnifying of the Objects viewed through this Glass to a Quantity of Water, and not to the Figure of the Glass which contained it.

The

The Weight and other Properties were known to the Ancients, and in Order to explain how Water ascends in a lifting Pump (which is occasioned by this Weight of the Air) they had Recourse to a certain imaginary Horror that Nature has for a *Vacuum*, so that rather than leave the smallest Space empty, she chose to violate her own Laws of Gravity and make the Water ascend.

And as one Folly produces a thousand more, the great Horror, that Nature testified for a *Vacuum* in this Pump, extended only to a certain Height, and beyond this perhaps was changed into Love, for there she admits as great a *Vacuum* in the Pump as you could desire.

But to quote still more Examples. *Nero* in his golden Palace (one of the most magnificent Effects of despotick Power in the the Universe) erected a Temple of Stone so very transparent, that Day-Light entered into it even when the Doors were shut. *Pliny* who gives us this relation, instead of contenting himself with affirming, that it was more transparent than Alabaster, says that it did not transmit the Light like other pellucid Substances, but included it within
itself:

itself: If this had been the Case, the Temple must have appeared much more luminous by Night than Day.

The Ancients were fonder of what raised their Admiration than encreased their Knowledge, and perhaps thought Experiments (which are the only Method we can arrive to a true Admiration of Nature) were too material to employ the Attention of a Philosopher, who ought to consult nothing but Reason.

They never imagined these Experiments would one Day lead industrious Posterity to such an Exactness, as to subject Flame to the Examination of a Balance, which was anciently regarded as a light Substance, for whose Sake they invented a particular Sphere where it was affirmed to ascend.

Nor could they foresee, that these Experiments could help us to calculate how much we daily lose by a continual insensible Perspiration, how many Million Tons of Water the *Mediterranean* Sea perspires in a Summer's Day, how much a Man decreases by the Weakness of the Muscles from Morning to Night? In short, that they should enable us to counterfeit Nature herself; and by certain chemical Mixtures, e-

mulate

94 Sir ISAAC NEWTON's *Theory*
mulate her *Etna's* and *Vesuvio's*, and imitate their Thunders much better than their own rash *Salmoneus*.

If an Ancient had been asked whether the Phosphorus of *Bologna*, for Example, shines by it's own Light, or by a borrowed one, it is impossible to know how many ridiculous Fancies they would have uttered by consulting Reason; whereas a Modern with a single Experiment has put the Matter out of all Question.

Pray, what is this Phosphorus, says the Marchioness, this Subject of the Absurdities of the Ancients and Experiment of the Moderns? It is a certain Stone, answered I, found in a Mountain near *Bologna*, which calcined with Fire, acquires the Property of shining in the dark like a Coal, if it has been exposed a little while to the Light of the Sun or only to the open Air. From this Quality it has obtained the fine *Greek* Name of Phosphorus, which signifies a Body that carries Light with it.—This is an Honour given almost to every Thing appropriated to learned Uses.

An Etymologist could not give a better Name to this Place than that of Phosphorus, which in our Language signifies the

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lucid Hill, and would thus consecrate it ever to Philosophy and Learning. We are much obliged to your Scholar, said she, for conferring so fine a Name on this Place, which certainly deserves it.

The Question, continued I, is at present reduced to this, whether the Phosphorus only takes in and imbibes the Light to which it is exposed, and from thence carried into the Dark, shines with a borrowed Light? Or whether the external Light puts it's Parts into such an Agitation, as to kindle a Light which it contains within itself, which by this Means loosed from it's Prison (if I may use that Expression) emits itself from the Phosphorus, which in this Manner shines by it's own Light. This last Supposition is more honourable for it, and better agrees with the fine Name it bears.

In Order to decide this Point, a modern Philosopher chose a certain Light, which would shew us whether the Phosphorus, when exposed to it, imbibed any of it's Rays, and by that Means reveal the Theft of this new *Prometheus*.

I already see, interrupted the Marchioness, how this Modern proceeded. He placed

placed the Phosphorus in one of the Colours of the prismatic Image, in Order to see whether it would acquire the Colour as well as the Light: If it did actually take the Colour, it is evident that it imbibes the external Light, and shines with a Splendor not it's own.

But if it does not take the Colour of the Image (since Colours are immutable and suffer no Alteration) the Light only agitates the Parts, and as you express it, loses it's Splendor out of Prison; and thus the Phosphorus shines not by a borrowed Lustre but from it's own, and ought rather to be compared with the Sun himself than *Prometheus*.

It is too true, answered I, that fine Ladies can be just what they please. You would be extremely in the Wrong, if you hereafter complain of any Want of Sagacity in *Physics*. What you have been describing, is the very Method which the *Bolognese* Philosopher took; and by this Experiment he confirmed to his Fellow-Citizen the Phosphorus, the Honour of shining by it's own Light. It is probable that the innumerable other Phosphori of the same Nature, lately discovered in *France* owed their Lustre to the same Cause: These
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by enriching Philosophy with new Wonders, have deprived the *Bolognese* of the Honour of Singularity, which now admits into Partnership only this single Instance in the whole philosophical World.

Do not Diamonds, the most valuable Phosphorus of Nature, shine in the Dark, because the external Light kindles and revives the internal Light, of which they are a rich and inexhaustible Treasure.

You may judge, replied the Marchioness, of my very great Sagacity in philosophical Affairs, when I never observe a Phænomenon which I every Day carry about me.

Perhaps, Madam, answered I, you were never in a Place dark enough to make this Observation.

Seignor *Boccari*, one Day visited a Lady in some Indisposition, who was resting behind a Screen far from the Air, and in a Place absolutely dark. The Lady asked him whether he had not a Light in his Hand; which he denied: But she constantly insisting she saw something glitter, the Doctor at last suspected it to be his Ring which shone in that profound Darkness, and perceived he had a long Time

without observing it, carried a Phosphorus upon his Finger.

You may judge of the Value he afterwards set upon this Ring. He made innumerable Experiments with it about the Time Mr. *Du Fay*, Father of so many Phosphori, found that Diamonds had the same Property.

How empty and barren must the Philosophy of the Ancients have been, said the Marchioness, and how copious, how charming is ours, whose Observations enhance even the Value of Diamonds?

I will give you still greater Evidence, answered I, how much the Ancients were to blame in their Neglect of Experiments, and you will be fully convinced that there is none even of those who seem of least Importance, but what is of great Service to *Natural Philosophy*.

That Froth we lately mentioned is an Instance; of this, for as little philosophical as it may seem to vulgar Eyes, it was the principal Thing by which Sir *Isaac Newton* found out the Cause of those various and almost innumerable Colours which we see in Bodies.

He

He had discovered in general, that certain Bodies appear of a certain Colour, because they reflect one Sort of Rays more copiously than the rest, and other Bodies of different Colours, because they reflect different Sorts; so that if Light consisted of only one Sort of Rays, there could be only one Colour in the World, nor would it be possible by Refractions and Reflexions to produce any new one.

This Discovery, which would perhaps have satisfied any other Philosopher, served only to excite the Curiosity of ours, and was but a Prelude to innumerable others.

Why should this Silk reflect the *Blue* more freely, than any other Sort of Rays? The Reason is this.

If one of those Bubbles, which are formed by blowing Water a little thickened with Soap, be covered with Glass, in Order to prevent it's being agitated by the Air, it will appear tinged with a great Variety of Colours, which spread themselves like so many Rings one within another, and encompass the Top of the Bubble. And in Proportion as the Bubble grows thinner, by the continual subsiding of the Water, these Rings slowly dilate and over-spread

the whole, descending in Order to the Bottom of it, where they all afterwards successively vanish.

The Variety of these Colours depends on the unequal Thickness of the Bubble of the Water in different Parts. But how to determine these Inequalities is not so easy, and perhaps would have been impossible to any but Sir *Isaac Newton*, who examined these Rings a thousand Ways, guided by his constant Tutor *Geometry* and a Spirit of Observation, whose Fertility seemed to encrease in Proportion to the Difficulties it encountered.

He discovered, that a certain determinate Thickness is necessary in a Plate of Water (for Example) in Order for it to reflect a particular Colour, and a different Thickness, to make it reflect any other Colour; and in general, that a less Thickness is necessary to reflect the most refrangible Rays, as *Violet* and *Indigo*, than those which are least refrangible as *Red* and *Orange*, all this is to be considered with Regard to a Substance of equal Density.

But when the Density in one Substance is less than in another, as the Density of Air compared with that of Water, a greater

er Thickness will be necessary in the first than in the last to reflect the same Colour.

After the same Manner he defined the Thickness necessary for the Transmission of Colours. From the Analogy or Similitude between the Plates of Substances which he considered, and the Particles of which Bodies are composed, he demonstrated that their Colours depend on nothing but the different Thickness and Density in their Particles; whence it follows, that some are more proper to reflect or transmit the Rays of one Colour, and others those of a different one.

This Analogy holds good in many Instances. Thus the one and the other are transparent: The Leaves of Gold and the Particles of many other Bodies transmit one Colour and reflect another, just as the Bubbles of Water which we have been mentioning.

These Rings appear of a various Colour when viewed in different Situations, the same happens in certain Silks in the fine Web of the industrious Spider, and as *Tasso* sweetly sings,

The Feathers so, that tender soft and
plain

About the Dove's smooth Neck close
couched been,

Do in one Colour never long remain,
But change their Hue 'gainst Glimpse
of *Phæbus* Sheen.

And now of Rubies bright a vermil
Chain,

Now make a Car-knet rich of Emeralds
green,

Now mingle both, now alter, turn and
change

To thousand Colours, rich, pure, fair,
and strange.

FAIRFAX's *Tasso*.

This appears very evident in those Powders
that Painters make Use of; for when they
are ground, (that is, when their Parts are
subtilised) their Colours change a little.
Bodies may in some Measure be regarded
as Stuffs, for their Threads, every one in
particular reflecting a particular Sort of
Rays, the whole Stuff appears of that
Colour, which is the Result of all the Rays
reflected from the several Threads of which
the Stuff is composed.

But

But what becomes of those Rays which are not reflected, says the Marchioness? Can you give an Account of them?

They are either transmitted, answered I, or stifled and extinguished, and are thus lost among the Particles of Bodies.

A Leaf of Gold placed between Light and the Eye is transparent, and appears of a greenish *Blue*; but a Collection of these Leaves placed one upon another loses both Colour and Transparency, the Rays which pass through the first Leaf being absolutely extinguished in passing successively through the rest.

White Bodies (to continue our Similitude) are Stuffs composed of Threads which reflect all Colours; Black, on the contrary, absorb and extinguish every Sort of Ray within themselves. For this Reason black Bodies heat much more easily than any other; and a black Cap, such as the *English* Ladies wear in St. *James's* Park, would not at all agree with your Walks in the *Italian* Sun.

White Bodies, as they reflect and drive every Sort of Ray from them, heat with more Difficulty than the others, which im-

bibe and absorb the Rays, and neither transmit nor reflect them.

From the same Causes arise the various Colours which we discover in the Air. The different Density and Thickness of the Exhalations and Vapours that rise from the Sea and Earth, paints the Heaven with varying Splendors, when rosy-fingered *Aurora* opens the Portals of the Morning, and calls back Mortals to their several Labours; or when *Vesper* invites them to repose and Pleasures. It is difficult however to trace a Cause by which the Colours at the rising and setting of the Sun are almost all the same, and succeed each other in a certain Order.

But this we certainly know, that the several Colours of different Persons Eyes proceeds from the Difference of Texture in the *Iris*, which is that Coat in the Eye that incompasses the Pupil.

The Variety of Fibres in the *Iris* kindles in some the imperious Look of a black Eye, in others the insidious Sweetness of the *Blue*. But it is not easy to assign a constant Cause why the *Northern* Nations should generally have white Hair and blue or grey Eyes, and we of a warmer Imagination,
and

and in a warmer Climate, should have our Eyes black as our Hair.

This System, however, will give us the Explication of a Phænomenon, which is perhaps inexplicable in any other, and will thus make us a Compensation for not being able to give a Reason for every Thing in particular.

The Phænomenon is this ; two transparent Liquors, the one *Red* and the other *Blue*, cease to be transparent when we look through both at the same Time. This Phænomenon, which so greatly surprized the Person who first observed it, is only a Consequence of the *Newtonian* Doctrine.

The one of these Liquors transmits only *Red* Rays, the other only *Blue*. Hence it follows that the Rays transmitted by the one will be extinguished and absorbed by the other, and the Eye which looks through each of them receive none.

And this Phænomenon is one of those whose Explication becomes a Demonstration of the System which is capable of explaining it.

That Opinion, said the Marchioness, that blind People can distinguish Colours by their feeling, now begins to appear credible

ble to me ; or rather is it not another Proof of our System ?

If our feeling was finer than it is at present, as fine as that of blind Persons perhaps is, could we not discover the Colour of a Body by feeling the different Thickness of it's Particles ? And thus we should effect by our immediate Sense, what a *Newtonian* would by his Calculation, if any one should acquaint him with the hidden Texture of Bodies.

Your blind Observators, answered I, might distinguish Colours by their feeling, even in the *Cartesian* System which you have now given up. For according to that, there must be a Difference in the Particles of Bodies of different Colours, in order that the Rays of Light may be differently modified.

A Proof like this, you perceive, is too ambiguous to deserve a Place among those we have already mentioned ; and there is the same Defect in what is said of a singular kind of Barometer, which the *Chinese* make use of to form a Judgment of the Weather by. This Barometer is a Statue placed upon a Mountain, which foretels the Changes of the Sky and Air, by varying it's own Colour. But

But had we not better seek for a Phænomenon nearer ourselves in the Nation of Gallantry and Politeness, which can be explained by the *English* System alone ?

Why should the Belles of that happy Country lay on more *Red* when they appear in the Boxes at an Opera, than when they embellish with their Charms the agreeable Walks of the *Tbouilleries* ? You lead Sir *Isaac Newton's* System, said the Marchioness, into Places where you would have found it very difficult to have led it's Author. Not if you, Madam, answered I, had been there.

The Light of a Candle is not so white as that of the Day, it has a yellowish Cast, and viewed through a Prism, *Yellow* appears the most shining Colour in it.

The less then the *Spanish* Wool is charged, or in other Words, the more it reflects other Rays besides the *Red*, the stronger will the *Yellow* appear, which is the predominant Colour in this sort of Light ; just as in a Chamber, where the Light enters through coloured Curtains, the Objects in the Chamber will the more easily take the Colour of the Curtains in Proportion as their own Colour is weak and faint.

This is evidently a Reason why the Quality of the *Spanish* Wool should be augmented for the Opera, that neither the Cheeks of the Ladies, nor the Eyes of their Admirers may lose any Thing, but find the same Advantages by the Light of the Evening as by that of the Day.

In the *Cartesian* System this wise Precaution would be entirely useless ; for if the *Spanish* Wool can modify the Light of the Day, it would in the same manner modify that of the Evening, be it of what Colour it will.

Must it not be a Mortification, says the Marchioness, for the Ladies of this happy Climate (if they ever have Time to consider) not to have a System in their own Country able to explain this Phænomenon in their *Vermilion*, but be obliged to call a foreign one from beyond Sea to their Assistance ? So much the more glorious is it for this to extend it's Empire over all Nations, even so far as to give them Lessons for the *Toilette*.

This is not the only one, answered I: If you would not have a *Blue* appear *Green* by Candle-Light (which might disconcert the Harmony of a Suit of Clothes, and cause innumerable

innumerable Chagrins;) you must be careful to choose it very clear, otherwise the *Blue* Rays mixed with the *Yellow*, which the Silk would reflect in greater Quantities by Candle-Light, might perhaps make it appear *Green*.

These are the *Gordian* Knots of the *Optic* Science, which this System dissolves without eluding the Oracle. These *Phænomena*, inexplicable to every other System, are without Difficulty explained in this. Every ambiguous Explication, every Proof that has not the force of Demonstration, is entirely rejected by the *Newtonian* Philosophy.

An Analogy, for Instance, discovered between the Production of Colours and that of other Things, which would supply another System with a Proof, can serve only for Ornament and Luxury to this.

It has been lately discovered that Insects, Men, Animals and Plants, instead of being continually re-produced by Nature, only unfold themselves from their respective Plants or Seeds (in which they are really contained) whenever they find a proper Disposition for it; that is, both Animals and Plants wait for a proper Repository, certain Juices,

Juices, Degrees of Heat, and other Things requisite to unfold them.

In the like manner Colours are not, as was once believed, produced at every Refraction, or Reflection, or some other similar Cause, but unfold themselves, if I may use the Expression, from the Bosom of Light, which contains them within itself, whenever it is refracted by a Prism, or reflected from the Particles of Bodies. And this Method of their Production seems much more agreeable to the universal Laws and established Order of Nature.

After the same manner appears the Colour of the Rainbow, the coloured Circles sometimes seen round the Sun and Moon, and those of a certain Light, which is often seen towards the *Northern* Parts of Heaven, and called *Aurora Borealis*.

Whatever Riches and Magnificence, replied the Marchioness, Nature has displayed in so great a Variety of Colours, she seems to have observed some Frugality in their Production. At least the *Newtonian* Nature appears to me a better OEconomist than the *Cartesian*.

The first has made Light a Magazine and Reservoir of Colours, which she produced

duced once for all infusceptible of any Alteration, only with a certain Disposition that renders them capable of being separated from each other, and shewing us by this Separation a Colour, which all united and mixt together they could not do; whereas the *Cartesian* Nature is every Moment obliged to give new Rotations to her Globules, and at every Refraction and every little Circumstance, consider in what manner to vary them. This must be an infinite Fatigue to her, and a very great Application of Thought.

That which had been jocularly said of *Malbranche's* God, in his System, may be applied to Nature, as *Des Cartes* has represented her, that they had neither Holidays nor Sundays allowed them to repose themselves.

But these Dispositions, answered I, which the Colours have to separate themselves, and which you so greatly admire, however convenient they may be to Nature by sparing her of so much Trouble and Thought, are sometimes very inconvenient to us.

Inconvenient! replied the Marchioness. Is it not to these we are indebted for the beautiful Variety of the World? How tiresom

and unpleasant would it be for us to see in all Objects a Repetition of the same Colour!

You apprehend it, answered I, to be a great Evil always to see the World in *Cbiaro Oscuro*, if I may use that Expression, and to be obliged to be dressed always in the same Colour, and what is worse, in a Colour like that of your own Complexion.

You may add, replied she, the Dread of losing a Topic of Discourse so very pleasing to the Ladies.

All these Misfortunes, answered I, and this terrible Addition of yours would happen, if the Rays had no Disposition to separate from each other, or if they were all of the same Colour.

The *Camelion* and wrinkled Faces would be considerable Losers too. Some of these, without the Trouble of changing their Skin, are discovered in the space of twelve, or at most twenty-four Hours, to change their Colours.

Astronomers, on the other Hand, would gain no small Advantage if the Rays were inseparable and of the same Colour. And what would not an Astronomer sacrifice to determine the exact Time of an Eclipse of *Jupiter's Satellites*, or to get a distinct Sight of

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of the Occultation of a Star by the Moon? These are a Set of People whose Looks are always directed to Heaven, and have very little regard for our Earth, any farther than as she is a Planet, and upon that Account enters into the celestial System.

This is all they regard in her, and therefore would feel very little Concern if the Ladies of this Planet were under an Impossibility of changing every Day the Colour of their Clothes, or subject to many other the like Inconveniencies.

But what Opposition, replied the Marchioness, can there be betwixt the Separability of the coloured Rays and the Observations of these Gentlemen, to make them quarrel with us for the Pleasure we receive from this Variety?

There is a very great Opposition betwixt them, answered I, and you will soon be convinced of it, when I tell you that the Separability of the Rays is prejudicial to the Perfection of Telescopes, which Astronomers regard as their very Eyes.

I before positively affirmed, that convex Glasses, of which Telescopes are composed, unite the Rays, which, proceeding from a Point, fall upon them into another Point.

But

But the Truth is, I spoke rather with regard to what they should do, than what they really do.

You seem, said the Marchioness, to have represented these Glasses in the same Light as Tragick Writers do their Heroes ; for these generally chuse to feign them what they ought to be, rather than imitate their Characters such as they really are.

It must be confessed, Madam, that I used a sort of poetick Licence, in telling you convex Glasses united the Rays into a Point, for it is not so truly a Point as a little Circle. This Circle, which is called the Aberration of the Light, proceeds from two Causes, the Figure commonly given to the Lens, and that Disposition which the Rays of Light have to separate themselves when they are refracted.

But indeed the Figure of the Lens is but a very small Obstacle, when compared with that of the different Refrangibility.

All Attempts therefore to render Telescopes more perfect, by giving a new Figure to the Lens, so as to make it unite the Rays truly in a Point, would be in vain.

In the *Golden Age*, of which the Poets give us so many fine Descriptions, when the Rivers

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flowed with Milk, and the Oaks distilled the fragrant Treasure of the Bee, when the Rams appeared in the Meadows arrayed in native Purple, and the Lamb displayed it's vivid Scarlet to the Sun, before the Hand of Art had taught the Fleeces to imitate different Dyes; in these happy Times, 'tis probable, the Telescope would have given a more distinct View of the Objects of Nature herself, painted in their genuine and beauteous Colours, when the Heart of Man, animated with purer Passions, appeared without Disguise, and Love had not yet learned to sigh by Custom or Art, nor ever wept from any Motive but Joy.

But in our Iron Age, in which both the Passions and Colours have degenerated from their original Purity, whatever be the Figure of the Lens, the Point where the *Blue* or *Green* Rays unite, will always be different from that of the *Yellow* and *Red*; there must always be an Aberration of the Light, and that little Circle will never become a Point.

This is a Circumstance very inconvenient for Astronomers, whose Affairs require that every Thing should be seen extremely distinct; but this Circle where the Rays unite,
instead

instead of the Point where they ought to unite, or the different Refrangibility, which is the Cause of their uniting thus irregularly, is a great Obstacle to the obtaining the Exactness which Astronomers desire.

These accurate Gentlemen, said she, must have Patience, and pray for the Return of the Golden Age. In the mean Time they must limit their Desires and Wants as other reasonable Men do, and be contented with the different Refrangibility of the Rays, instead of that very great Distinctness in Objects which they desire.

It is not possible to have all Things at one Time in this World. Is the Knowledge of so many fine and surprising Properties of Light so very small an Acquirement, that they cannot be satisfied without something more? Their Desires and their Wants however are so reasonable, said I, and have so great a Connexion with those of other People, that *Sir Isaac Newton* has thought upon a Method of satisfying them. With his own Hand he ground Glasses for Telescopes of a new Figure, in Order to correct the Deficiency of ordinary

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nary Lenfes. Then was the Time to have all, or hereafter hope for nothing.

While his Mind was employed in this Thought a new Scene of *Optics* opened to his View, he discovered the different Refrangibility of the Rays, laid aside the Work he had begun, and invented a new Telescope, in which a concave Mirror supplies the Place of what in ordinary Telescopes is called the Object Glass, and which had the greatest Share in the Aberration of Light.

I myself have seen the first Telescope of this Sort, worked by those Hands which had pointed to the Planets their Road in the vast Deserts of a Vacuum, and opened to Geometry the immense Career of Infinity.

This Instrument is preserved in a City of *England*, where Philosophy and Politeness hold a mutual Empire; with this are treasured up those Prisms which the first Time differently refracted the Rays of Light in the Hands of our great *Philosopher*, separated it's Emeralds, Hyacinths, and Rubies, and unfolded to human Eyes the celestial Riches of the lucid Robe of the Day.

In the Reflexion from a Mirror the Rays are not separated, as they are in being reflected

reflected through a Lens, consequently the Objects may be much more distinctly seen.

It has been tried in *Italy* (for even among us Truth and Sir *Isaac Newton* have their Admirers) that if a distant Object, the one half *Red* and the other *Blue*, be viewed with an ordinary Telescope, this Instrument must be considerably shortened to give a distinct Sight of the *Blue* half, and on the contrary must be lengthened to shew the *Red* distinctly; whereas in Sir *Isaac Newton's* Telescope they appear equally distinct with the same Length.

This reflecting Telescope has besides another Advantage over the ordinary ones, for one of Sir *Isaac's* Invention one Foot long, is equivalent to one of twelve in the common Sort; and one of forty Foot, to a Hundred. And this is another Convenience to *Astronomers*, who find great Difficulty in managing long Telescopes.

It is well for us, replied the Marchioness, that these *Astronomers* will be now contented, for it seemed before a pretty difficult Matter to please them.

How is it possible, answered I, for them not to be satisfied with Sir *Isaac Newton*, who seems in every Thing to have studied their Advantage?

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His System of *Optics* (besides procuring them a more convenient and perfect Telescope) has vindicated the Honour of Astronomy from an Aspersion, which seemed in some Measure to discredit it in the Eyes of the World.

You are not ignorant that the Honour of this Science among Men, consists principally in it's exact Prediction of Eclipses and Events, no less observable to philosophical than to vulgar Eyes.

Thales of Miletus was revered among the *Greeks* like a God, for having predicted the Year in which an Eclipse of the Sun was to happen, that is, when the Moon would be interposed betwixt us and the Sun, and by that Means deprive us of his Light.

As Astronomy successively became more perfect, what would have caused a Temple to be erected to a *Thales*, would only disgrace a *Hally*, *Cassini*, or a *Manfredi*.

The Observatory is required to shew the precise Minute in which the Eclipse will happen, and it's exact Quantity, or in other Words, whether the Moon will hide the whole Body of the Sun or only Part, and how much precisely the obscured Part will be. Not

Not long since all the Calculations of the most celebrated Astronomers had predicted two total Eclipses, whose principal Merit consists in not being very common, and introducing a sudden and unseasonable Night. An Event, which though foretold and expected, never fails to terrify that whimsical Species of Animals called Man. That Asylum of the strongest Contradictions, nourished by long Hopes, impetuous Passions, the most evident Truths and the most palpable Error, capable of making Attempts beyond the Powers of his Nature, and subject to Fears which his Reason contradicts.

All the Philosophers got up very early on the Days appointed for this Spectacle, in Order to prepare themselves for Observation.

They all waited in the midst of the Eclipse to see the Light of the Sun entirely extinguished, and a most gloomy and profound Night emerge from the Splendor of a fine Day. But the Event was contrary to their Expectations.

There remained round the Moon a luminous Ring, which made some falsely take them for annular Eclipses.

When

When the Sun is nearest to the Earth, and the Moon at the greatest possible Distance, if there happens in these Circumstances a central Eclipse, as they call it, the Moon cannot hide all the Sun, but there remains all round it's Edge a luminous Border resembling a Ring.

But Astronomers gained nothing by this Explication, which was of no Signification in the present Case, and the World was but ill-satisfied with Astronomy which is now believed an Impostor.

The one murmured and were discontented, while the other racked their Brains to find the Reason of this Ring, which had the Confidence to appear in Spite of all their Calculations.

Some laid the Fault upon a luminous Atmosphere which encompasses the Sun, as our Air does the Earth, and became visible when the greater Light was obscured. Others accused the Atmosphere of the Moon, which being illuminated at the Time of the Eclipse appeared like a lucid Ring. But unhappily for them the first was innocent, and the second seemed so doubtful, that it might appear rather a

Mark of their Consternation, than an Explication of the Phænomenon.

I find myself greatly affected with Concern, said the Marchioness, for these unfortunate Astronomers, abandoned by Heaven and Earth, and in the utmost Danger of losing their Reputation. It is however the Office of Humanity, to have Compassion on the Afflicted.

They must have Recourse, answered I, to the *Newtonian* Oracles, if they would silence the Voice of Calumny. These were the Anchor of Hope in the present calamitous State of Affairs.

When the Rays of Light pass near the Extremity of a Body, they bend and incline towards the Body itself, and are thrown into it's Shadow. If the Edge of a Knife be placed in a Ray of Light in a dark Chamber, the Rays which pass at some Distance from it, appear to bend and approach nearer it's back.

Grimaldo was the first who observed this Quality, which is called the Diffraction or Inflexion of Light, and our Philosopher afterwards illustrated it with many new Experiments, and though he did a great deal desired to do still more.

The

The solar Rays, which pass near the Edges of the Moon, must bend and cast themselves into the Shadow of the Moon herself.

Observers then, who in the Time of the Eclipse are immersed in this Shadow, must receive these Rays bent from the Edges of the Moon, and see a luminous Ring round her; a Sort of Twilight resembling that which we see in the Evening, and sometimes in the Morning at the Horizon.

The only Difference between our Twilight and this Ring is, that the first is occasioned by the Refraction which the Light suffers in coming from the celestial Spaces into our Air; and the second by the Diffraction which it undergoes in passing near the Moon: But both are composed of Rays, which do not seem destined by Nature for that Purpose.

To give a stronger Confirmation that this is the true Reason of this Ring, there have been made several Globes of artificial Moons, which exposed to the Sun and full Moon, have shewn upon the Earth the Effects of that Diffraction, which had appeared so fatal to Astronomy in Heaven.

Astronomers, replied the Marchioness, have certainly great Reason to be satisfied with Sir *Isaac Newton* and his Diffraction, which has delivered them from such imminent Danger. But I must confess myself to be thoroughly discontented with it.

Will you permit me to ask why those Rays, which pass at some Distance from Bodies, must be inflected and bent? The Idea which this new Property of Light presents me with is so very strange that I cannot conceive it.

I find, answered I, you are more difficult than the Astronomers themselves. You desire to know the Cause of this Diffraction. Well, I will inform you, but you must promise not to draw back and frown, when I tell you it is the Attraction which Bodies exercise upon Light.

The Attraction, said the Marchioness, with an Air of Surprise! You say this either to laugh at my Credulity, or punish my too presumptuous Curiosity. What do Bodies attract the Light as a Loadstone do Iron?

What ill Consequences would arise supposing it were so? answered I, or rather how great an Advantage has the Science of *Optics* in particular, gained from this

Attraction between Light and Bodies, as all *Natural Philosophy* in general has from the universal Attraction of Matter, of which that between Bodies and Light is a Consequence?

Attraction is the Key of all Philosophy, the great Spring that actuates the Frame of Nature; the universal and mysterious Force discovered and calculated by Sir *Isaac Newton*, proposed to the Examination of Philosophers by the great Lord *Bacon*, and obscurely sung by the *British Homer*.

The Marchioness recollected herself, and looked very attentively in my Face, to see whether I spoke in Earnest. Do you tell me seriously, she replied, that all Bodies are attracted; this is quite a new World to me, in which I am an utter Stranger and Foreigner.

Do not be discouraged, said I, for this has happened to many professed Philosophers, who have exclaimed against this Attraction; affirming, that to admit it is introducing into Philosophy certain occult Qualities which the Ancients supposed in Bodies, such as Sympathy, Antipathy, and the like, whose Numbers multiplied with the Phænomena themselves, by the Assist-

ance of which they in an Instant explained, or rather perplexed every Thing.

They farther add, that it is recalling those occult Qualities from those Colleges of *Europe*, where Ignorance still affords them an Asylum to introduce them into true Philosophy, from whence they for the Happiness of Mankind had been banished by the Authority of Reason.

But all these Objections signify nothing, for Attraction is so far from being an occult, that it is an extremely evident Quality of Matter, on which clearly depends the Explication of Diffraction, Refraction itself, and innumerable other Things.

It is not a Name without Reality, invented to explain two or three Appearances, but a general Principle diffused through all Nature, and extends from the smallest Grain of Sand to the greatest Planet.

The *Peripateticks* resembled those Ancients, who for every little River or Tree, nay even for the Fever or the Cholic, created a new Deity. But Sir *Isaac Newton* appears as a great Philosopher, who by the Help of Attraction established the Existence of an all powerful, infinite and only God, the supreme Director of the whole Frame of Nature.

Sir

Sir *Isaac Newton*, when he affirms, that Light in passing near the Extremity of Bodies is attracted by them, does not pretend by that to give a complete Explication of Diffraction; all he undertakes is only to point out that Property of Matter, on which the Explications of Diffraction depends, but the Cause of this Property is to seek.

This he commits to those Philosophers who have superfluous Time enough, to throw away in Search of a Thing which appears above the Reach of human Faculties.

In short, all that Sir *Isaac Newton* attempts, is to establish Facts and the general Properties of Matter, and from these geometrically to deduce Phænomena and Effects; and this is the Order we have hitherto observed in our Discourse upon *Light and Colours*.

This new Property, replied the Marchioness, is of a Nature which my Thoughts cannot so easily come into.

This is one of those historical Facts, of which it is impossible to get a perfect Intelligence without entering into the Cabinet.

I understand, or think I understand, how the Rays of Light are differently refrangible. This among many other Things is very intelligible. But that Bodies should attract the Light, and that at a certain Distance too, and in general that every Thing should be mutually attracted, seem to me very difficult to conceive.

Some Remains of *Cartesianism*, answered I, which you are not entirely free from, deceives you in this Point.

Perhaps you have hitherto flattered yourself, that Refraction arises from some one of those Causes, which in treating upon the *Cartesian* System were rendered so familiar to you, and upon this Account you think Refraction more intelligible than Diffraction. Sir *Isaac Newton* himself appears in some Places to have indulged the Prejudices of this Sect.

In Order to speak the Language then current in Philosophy, he said, that Attraction perhaps might be the Effect of the Impulse of a subtile Matter proceeding from Bodies. But in Fact, after he had proved the Heavens to be empty, and the celestial Bodies mutually attracted in those vast Spaces, what Room did there remain
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for the Impulse and subtile Matter? He seems to resemble certain Authors, who to make their History agreeable to any particular Nation, are sometimes obliged to intersperse it with fabulous Episodes, and give it the Air of a Romance. Is it not a great Reproach upon Mankind, that even the Truths of Sir *Isaac Newton* were obliged to use some little Artifice, in Order to meet with a Reception among them?

Is not this rather an Artifice of yours, interrupted the Marchioness, to surprize me by a Motive of Honour, and in this Manner make me believe that I have no better Conception of the subtile Matter than of Attractions, or how Bodies should be indued with Motion, for Example, than with that which you rightly term a mysterious Force?

Your Illusion, answered I, proceeds from hence, that you are familiarized to one Idea and not to the other. You every Day see Bodies move and mutually communicate their Motion, but you have never seen them attract each other.

You are surprized at Attraction, while Motion appears to have no Difficulty. In this you differ from Philosophers, who

like Poets for the Solution of any difficult Point, are obliged to have Recourse to the Divinity, for the Explications both of Motion and it's Communication.

A *Portugueze* accustomed to reverence Spectacles upon the Nose of the gravest Persons, as a Mark of the greatest Dignity, would probably be surprized to see a *Chinese Mandarin* let his Nails grow to an enormous Length for the very same Reason.

And the Cause of his being surprized in one Case and not in the other is, that a long Habit has connected in his Mind the two Ideas of Honour and Spectacles, which have nothing in common with each other, but has not connected those of Honour and long Nails.

I shall at least deserve more Compassion than the *Portugueze*, replied the Marchioness, because the Surprize of seeing Matter united to Attraction instead of Motion, will, I believe, be common to all Countries.

As universal and excusable as this Surprize may be, I answered, it must however at last submit to Reason. If you had never seen Bodies move, it would have been impossible for you to guess how Motion would be joined with Extention and mutual

Impenetrability, which would be all the Qualities you would then have been acquainted with.

It is Observation which has made you admit this Property in Matter, and Observation must make you allow Attraction.

We are as yet but Children in this vast Universe, and are very far from having a complete Idea of Matter ; we are utterly unable to pronounce what Properties are agreeable to it, and what are not.

We see Bodies in very near the same Manner as a Person, who should receive his Senses by little and little. It would be certainly great Temerity in him to affirm, that there cannot be a Property in Matter capable of moving the Eye, and should assign as a Reason for this Assertion, that he had never been able to observe any such Property.

This Person would not act like the *Cartesians*, who form a World and a Man just as their own Caprice directed them ; he would grow more cautious in limiting the Power of Nature and pronouncing the Qualities of Bodies, in Proportion as he should acquire new Senses, which would

every Day furnish him with fresh Discoveries of these Things.

Philosophers may be said in some Degree to acquire new Senses, or rather those they had before become every Day more refined, and are by that Means in a Capacity of perceiving what perhaps they had once no Idea of.

Hence it evidently follows, how very cautiously they ought to proceed in assigning the Number of Properties in Matter.

It signifies nothing to say, that some are more intelligible than others, for to speak ingenuously, they are all equally mysterious to us.

Will you any longer make a Difficulty, Madam, to admit Attraction as a Property of Matter when it is proved so many Ways, and principally by the heavenly Phænomena, which give the most shining Testimony to a Thing, that you yourself so evidently demonstrate the Truth of. I assure you for my Part I shall never look for any farther Demonstration of it than what you afford.

But I, replied the Marchioness, shall not be so easily satisfied, for I have need of the daily Attestation of all Heaven itself, to convince

convince me of a Thing which yet appears so strange and surprising.

It is absolutely needful then, continued I, to give you a full Conviction of it. And indeed it would be doing a great Injury both to Sir *Isaac Newton* and yourself, to endeavour to make you believe a Thing without giving you good Reasons.

I am sorry this System cannot be explained to you, with all the Force of those Demonstrations and Calculations which accompany it; without these you must certainly lose a great deal. I will have Patience, said she, if I cannot see it in all that Lustre in which it would appear to a *Mathematician*, and will act like those *Virtuosi*, who when they cannot get a Picture content themselves with a Copy of it.

I flatter myself you will render it as like the Original as possible. It is at present too late, I replied, for this Expedition. To Morrow we will ascend into Heaven, and from thence bring Attraction down in Triumph to Earth. Some astronomical Facts and Propositions in Geometry, which you may safely believe upon the Word of Sir *Isaac Newton*, shall serve for a Hyppogryph or flying Car to transport us to the Skies.

ENTER-



ENTERTAINMENT VI.

*An Exposition of Sir Isaac NEWTON's
Universal Principle of Attraction.
The Application of this Principle to
Optics. The Conclusion.*



EX·T Morning after the first usual short Compliments, the Marchioness (as impatient for Attraction, as she had been before for Colours) put me in Mind that it was Time to mount our Hippogryph, and give him the Reins.

You will not find him tire, Madam, replied I, in so short a Way, provided I can but exactly remember some horrible Numbers which it will be necessary to make use of.

I shall first inform you then, that all the Planets revolve at several Distances about the Sun : He (some nine hundred thousand Times larger than this Earth) forms, as it were, the Centre of their Motion,

tion, while he is himself lulled in the Bosom of calm Repose, and remains undisturbed in majestick Ease. Nearest to the Sun, at the Distance however of about two and thirty Millions of *English* Miles, (be pleased to observe, Madam, that the Miles of that Country are peculiarly consecrated to Celestial Mensurations) is placed the little Planet *Mercury*; next to him, fifty nine Millions of Miles distant from the Sun, the lucid Orb of *Venus* rolls; then our Earth, at the Distance of fourscore and one Million; next the ruddy *Mars*, at one hundred and twenty three; at four hundred and twenty-four the stately Bulk of *Jupiter*; and lastly, the immense Sloth of *Saturn* at seven hundred seventy-seven Millions of Miles Distance.

All these Planets observe this natural immutable Order in their Motions; viz. those which are nearest to the Sun, compleat their Revolution or Orbit in a shorter Time; and those more distant from him in a longer. *Mercury*, for Example, finishes his in fourscore and eight Days; *Venus* trips it round in two hundred and twenty-four, the Earth performs her Course, as you already know, in the Space of one Year.

Year. *Mars* compleats his in two, *Jupiter* takes up almost twelve, and *Saturn* requires about twenty-nine Years and an half.

There is in all this such a mutual Dependance and Relation between the periodical Revolutions of the Planets, and their respective Distances from the Sun, that so soon as we can ascertain the Distances of any two (as of the Earth and *Jupiter*) and the periodical Time of the Revolution of one of them (of the Earth for Instance, which takes up a Year) we can thence by an infallible Rule find the periodical Time of the others. I should have a much clearer Idea of your Meaning, said the Marchioness, if I had first read *Fontenelle's* Plurality of Worlds, to convince me of the Motion and Agility of this same Earth. As you are now so great a Proficient in Philosophy, I replied, you must seek the true Demonstration of this Motion in *England*.

There has been observed certain Appearances in the Stars, which some imagined to be Consequences of this Motion, though they were themselves Assertors of this Motion; but others who examined it more strictly, have discovered these Appearances to be contrary to the Laws of such a Motion.

tion. The Motion of Light which is a considerable Time in coming from the Stars to us, must strangely vary their Appearances, and ought to be considered in Conjunction with the Earth's Motion round the Sun, in order to give a right Decision of the Question.

The Sagacity of the *English* Philosophers has in Fact united these two Motions, and by this Means they explain these surprising and various Appearances, which in any other System are absolutely inexplicable. And thus we have attained to the Certainty of a Thing proved a thousand Ways, but never strictly demonstrated by any.

The five Planets in whose Number we may safely replace our Earth, are called Primary, to distinguish them from other subaltern Planets which revolve round a Primary, as the Moon does round our Earth ; the four Satellites of *Jupiter* round that Planet, and five round *Saturn* ; and these Subalterns are called Secondaries. These last agree with their Primaries in observing this Order, that the nearest complete their Orbit in a less, and the most distant in a greater Time ; and they keep
this

this Law with the same Exactness and the same Relation as their Primaries do.

Another Law in which the primary and secondary Planets agree is, that they do not describe equal Parts of Orbits in equal Times, but such Parts of Orbits as to make their Areas equal. That you may better understand this other Law of their Motion, you are to suppose that the Orbit of a primary Planet is very near a Circle, which the Sun is not placed directly in the Center of, but a little on one Side. Imagine a Line to be drawn from that Point of the Orbit where the Planet now is, to the Sun, and another Line to be drawn from that Point where the Planet will be twenty-four Hours hence; the Space contained betwixt the two Lines drawn to the Sun, and that Part of the Orbit which the Planet has described in twenty-four Hours, is called the Area, and will be equal to another such Area, that the Planet will describe in twenty-four Hours more; and thus in equal Times the Areas will be always equal. The Areas then, as Astronomers express it, are proportional to the Times. Thus if instead of twenty-four Hours we put twelve, which is one half, an Area described in those

those twelve Hours will be only one half of the Area described in the twenty-four ; and so, if we take a third or fourth Part of the Time, the Areas described in the third or fourth Part will be the third or fourth of those described in the first Time ; and if that Time be doubled, the Area described in it will be doubled likewise, and so on. This Law, which the primary Planets observe with regard to the Sun, the secondary Planets observe with regard to the Primary, round which they revolve ; and this Primary is the same to it's Satellites, as the Sun is to the Planets of the first Order. I am extremely pleased, said the Marchioness, with the Agreement between these two sorts of Planets. I regard the Sun as Monarch of the immense planetary Realm, in which the primary Planets are the Grandees and Nobles ; some of these possess certain Districts, where they exercise the same Jurisdiction in little, which their Sovereign does in great, but all shew their Dependance by revolving round him alone. Our Earth is in Possession of a little Province, where she exacts Obedience from the Moon ; and though she cannot vye with

Jupiter

Jupiter or *Saturn*, who have a greater Number of Dependants, she is certainly superior to *Mars*, *Mercury*, and *Venus*, who have none.

Your Similitude, answered I, would be juster in the *Cartesian* System of Vortices, where these Jurisdictions seem very well established ; and it would be the more so, because this Philosophical Poetry is fond of imbellishing itself with Comparisons and Similies, and sometimes makes them even serve for Reasons. But the two Laws I have mentioned to you will not suffer it. Indeed it is pity we are obliged to abandon these Vortices, that present the Mind with so clear, so natural and simple an Idea. The Planets, say the *Cartesians*, revolve round the Sun, because a certain Fluid in which they are immersed turns round too, and carries them with it like little Skiffs forced along by the Current of a River. The secondary Planets revolve round their Primaries for the same Reason.

Nothing seems to be more evident than this. But the Misfortune is, that these Planets are not contented with barely turning round, but will do it by certain inviolable Laws, that entirely destroy all these imaginary Systems. Either

Either these two Laws cannot agree with the Vortices, or agree so ill, notwithstanding all the Efforts to that Purpose, that one of their most illustrious Defenders confesses, after all he has done in their Support, he doubted whether those, who refuse to admit them, would not be confirmed in their Opinion by the very manner in which he has endeavoured to defeat it. Besides, these Vortices, are pressed by so many other insuperable Difficulties, that Heaven itself seems to have conspired in the Destruction of this fine Poem.

Far be it from us, replied the Marchioness, to oppose the Decrees of Heaven. On the other Hand, I cannot reconcile myself to the Idea of a Poem in Philosophy. What is this Philosophical Poetry to which I cannot assign a Place in my Thoughts? It ought to content itself with influencing the Passions of Men as Men, but it has nothing to do with the sole Passion of Philosophic Men which is Truth.

The *Newtonian* Principles, answered I, have inspired you with very rigid Sentiments; but this Poetry, that thinks itself too much limited in the vast Field of human Passions, shall give you no further Trouble. Comets,
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the most declared Enemies in all Heaven to their Vortices, will, I believe, be sufficient to overthrow it, for they seem to be made expressly for the Destruction of Systems. It has been established, by Virtue of I know not what, but however the Philosophers have very readily believed, that the Matter of the Heavens was incorruptible, and that every Thing there flourished in a perpetual Youth, insusceptible of the Changes and Vicissitudes which happen here below. The Comets at first appear almost naked, but in their Approach to the Sun are clothed with a formidable Tail, of which they gradually divest themselves as they recede from him, and so return back naked as they came. And in this manner is the System of the Incorruptibility of heavenly Regions, in great Danger of being overthrown by these impertinent Comets. And this perhaps is the Reason why they were degraded from their celestial Seat as worthless Meteors formed by the Vapours and Exhalations of our lower World. But they would not remain long there; for besides many ancient Philosophers, who considered them not as one of the transient, but durable Works of Nature; the Astronomers, who

who must have their Share in a Thing above us, assure us, that they are very distant from the Earth, and some of them farther off than the Sun himself. These Comets, said the Marchioness, are very bad Omens to Systems, if not to crown-ed Heads. These were not all the Troubles, said I, which they gave Philosophers. When they were placed among the Celestial Bodies, they could not agree with that Solidity which had been granted to the Heavens upon the Word of *Aristotle*; in order therefore to avoid their demolishing and breaking to Pieces the whole Universe in their Passage through the *Aristotelian* Heavens, it was necessary to resolve upon making these last fluid.

When the Heavens were thus made fluid, they became Vortices, against which these factious Comets renewed their Enmity with more Violence than ever, to destroy an agreeable Imagination, received by the World with so much Applause, and which was defective in nothing but Truth.

Some Comets have made no Difficulty to cross the Orbits of all the Planets, proceeding almost directly from the superior Part of the Vortex to the Sun. Others have
moved

moved in a Course absolutely contrary to that of the Planets, without meeting, either in the first or second Case, any Resistance in their Motion, which must necessarily have happened, if there was a certain Matter that whirled round the Sun; and this at several Distances from him with the same Rapidity as the Planets supposed to swim in those Vortices. Their Motion would have been so weakned, that turning round the same Way as the Planets do, they would have soon yielded to the irresistible Force of the Vortices; not unlike the unfortunate Barks, which guided by an unskilful Pilot or a malignant Star, are shipwrecked in the horrible Cataracts of the *Chinese* Rivers, notwithstanding all the struggling they can make to the contrary.

In short, these Comets have in every Instance acted directly opposite to the Laws of Vortices. So that to rescue them from the continual Injuries they receive from these implacable Enemies which lay hold on every Occasion to commit all Sorts of Hostility and Impertinence; I see no other Remedy than to destroy and banish these unhappy Fluids for ever from the System of the World.

Your

Your Expedient, replied the Marchioness, is no less violent than that sometimes used in War, when one Party destroy and ruin a Country which they cannot defend against the Enemy. And thus they make the same Sacrifice to their Weakness as you do to Truth. This is a Sacrifice at which I cannot be displeased, especially as it puts me into a better Capacity of listening with more Tranquillity to the new Principle, upon which the celestial System is built.

Sir *Isaac Newton*, continued I, founded his Scheme in *Geometry*, which we may call his native Country. He began with demonstrating, that if a Body in Motion is attracted towards a Point either moveable or immoveable, it will describe about this Point equal Areas in equal Times; and in general, that the Areas will be proportional to the Times: And on the contrary, if a Body describes, round a moveable or immoveable Point, Areas proportional to the Times, it will be attracted towards that Point; that is, the Body will have such a Tendency towards the Point, that if every other Motion which impels it a different Way should cease, the Body would directly unite itself to that Point, just as Bodies

here below, when left to themselves, fall directly upon the Earth.

This Principle, interrupted the Marchioness, is equally applicable both to the primary and secondary Planets. Each of these describe Areas proportional to the Times, round the Point about which they turn (if the Sun, our Earth and *Jupiter* may be termed Points.) The primary Planets then are attracted by the Sun, and the secondary by their respective Primaries about which they revolve. Is not this a necessary Consequence?

It is without Dispute absolutely necessary, answered I. But remember, Madam, this is a Deduction of your own. This Punishment is just, since you have made so much Difficulty to admit the Principle of Attraction.

You say then that there is a Force in the Sun which attracts the Planets to him, and after the same Manner, a Force in the Planets that attracts their Satellites; and this attractive Force joined with another by which they all move from West to East, is the Reason why the first revolve round the Sun, and the others round their Primaries, in a certain Order.

The

The Ancients, in Order to explain this difficult Phænomenon, built solid Heavens and created Intelligences to put them in Motion. On the other Hand, *Des Cartes* had embarrassed the whole Universe with the great and magnificent Apparatus of his Vortices. But after all, the Motion of the heavenly Bodies is by Sir *Isaac Newton* reduced to the most simple, yet to the most noble Phænomenon in the World, which has been rendered much more familiar in *Europe*, than is agreeable to some Persons. In short, it is no more than that of a Cannon Ball, which would of itself proceed in a direct Line, if the attractive Force of the Earth did not draw it nearer to itself continually, and oblige it to move in a Curve, so uniform and simple is Nature in it's infinite Variety. The Ball very soon falls to the Earth, because the greatest Force we can possibly give it, is but little when compared to the vast Extent of this Globe. If it were possible for human Weakness to throw one from hence beyond *Peru*, it is demonstrated that we should acquire a new Satellite; it would like the Moon revolve about our Earth, only it's Motion being necessarily very soon weakened from the

continual Resistance of the Air, while the gravitating Force would lose nothing of it's Strength, this new Moon would at last fall and destroy every Thing it lighted on, after we had heard it make a horrible hissing over our Heads.

All this you explain in two Sentences ; an evident Proof of the Significancy of a Lady's Words. What you have said is certainly a great deal, but not all. It still remains to know by what Law this attractive Force acts ; that is, whether it be the same at all Distances from the Sun, or whether it grows weaker in Proportion as the Distance is greater.

I will resolve you this Question, the Marchioness replied, when you have furnished me with as many Hints for that Purpose as you did when I told you that the Planets are attracted by the Sun ; and I hope you will afterwards make as genteel a Commentary upon me as you did in the other Case.

That Law, answered I, of describing Areas proportional to the Times observed by every particular Planet, furnished Sir *Isaac Newton* with Means to discover the attractive Force of the Sun ; and that
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other Law which they observe, of describing their Orbits in a greater Time, in Proportion, as they are at a greater Distance from the Sun, and that with a certain Relation between these Times and their Distances, helped him to find out that the attractive Force diminishes as the Distance from the Sun increases.

The attractive Force diminishes with this Proportion, that it is always so much less as the Square of the Number which expresses the Distance from the Sun is greater. In Order to understand this Cyphering (which perhaps at first Sight may appear very formidable) it is necessary to acquaint you, that the Square of any Number is nothing, but that same Number multiplied by itself; as Four for Instance is the Square of two, because twice Two makes Four, that is, Two multiplied by itself gives Four.

I may now safely venture to propose you a Problem, that as you have lately explained the Phænomena of *Natural Philosophy*, you may now undertake the Solution of mathematical Problems: After this I do not see what you can do better than to shew some Sort of Gratitude, and discover

the Truth to him, who has conducted you into it's most abstruse and retired Paths.

The Problem I shall propose to you is this: Suppose the Earth's Distance from the Sun to be one, and Jupiter's Distance from him to be about five (considered with Respect to that of the Earth) the Question is, to know how much the Sun's attractive Force will be diminished at the Distance of Jupiter?

Give me a little Time to consider, answered she, with some Impatience, for the Solution of a Problem is no trifling Affair. You have informed me that the attractive Force is so much less, as the Square of that Number which expresses the Distance is greater. The Square of one which is the Earth's Distance from the Sun, is one.

And at the Distance one, answered I, the Force is supposed to be one, and the Question you are to resolve is, How much that Force will be diminished at the Distance of Jupiter from the Sun, which is five?

The Square of five, answered she, with great quickness, is twenty five. If the attractive Force must be so much less as this Square is greater, it follows that in Jupiter it is twenty five Times less than in the Earth.

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Earth. Is not this the Solution of your Problem? And may not I, like *Archimedes*, run crying about, *I have found it, I have found it?*

Yes certainly, answered I, but not in the same Circumstance as he did, when his Impatience was so great, as to make him run precipitately out of the Bath. The Mathematicians ought rather to act as *Pythagoras* did upon the Discovery of a certain Truth, and sacrifice a Hecatomb to solemnize this Day, which gives them Liberty to imbellish and brighten their gloomy Catalogue by your Name.

The Law that the attractive Force observes of growing weaker at various Distances from the Sun, is the very same to which all other Qualities that flow from Bodies are subject; as Smell, Sound, Heat, and which most nearly concerns us, Light. Thus when you believe yourself to have solved only one Problem, you have in Reality solved two.

Is then, replied she, the Light of the Sun as well as his Attraction, twenty five Times less in Jupiter than with us?

The very same Number, answered I, serves equally for both. After the same

Manner you will find that the Attraction, the Light and Heat of the Sun, must be ninety Times less in Saturn than with us. The Twilight of our farthest *Laplanders* would be there the finest Summer Days, and in the most raging Dog-star of that Planet, our Seas hardened with perpetual Ice, instead of swift sailing Vessels, would groan under the Weight of heavy Chariots; whereas in Mercury they would, even in the Depth of Winter, be dissipated into thin Vapours (occasioned by his extreme Proximity to the Sun) and would thus leave their Bottoms dry, and present to Pilots a horrid Gulf, a dreadful View of the Terrors of the Deep; and to *Naturalists* a beautiful Scene that would furnish them Materials to enrich their Musæums.

You see, answered she smiling, how many fine Discoveries I have made without perceiving any Thing of it. It is however true, that great Affairs are generally brought to pass we know not how, and we are at last amazed to find them effected.

In human Affairs, answered I, it is ascribed to their good Fortune, if the *Cæsars* and *Alexanders*, after proposing only one End, acquire another which they never dreamed

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dreamed on. It often happens, that those very Persons, who are called fortunate, gain that Name by some Events very different from what they intended. The Inventor of Gun-powder, it is probable, proposed a quite different End to his Studies, than the Discovery of a Secret to destroy Mankind with the greater Facility ; and that Person who found a new World sought nothing but a more expeditious Way to the richest Part of the old.

On the other Hand, in true *Natural Philosophy* and *Geometry*, the *Cæsars* and *Alexanders* are more common. It is very seldom that we find only what we sought. The Discovery of one Truth frequently produces many others, which appear in Spite, as it were, of those who seemed to disregard them. Any one, who carefully seeks that Law by which the attractive Force ought to act at various Distances, will at the same Time discover that universal Law by which all the Qualities which flow from Bodies are governed. *Natural Philosophy* afterwards illustrates this general Truth with peculiar Experiments, and in some Measure translates the abstruse Hieroglyphics of the learned Tongue into vulgar

H 5. Language ;

Language. That Decrease of the Attractive Force which immediately concerns Light, is demonstrated by a very easy Experiment, which we may try this Evening, if you are not already sufficiently tired with Philosophy and Experiments.

Suppose one single Candle to be placed in a Room, and recede from it to such a Distance as not to be able to distinguish the Characters of a Book or a Letter, unless perhaps it were a Billet-deux, which may be read at any Distance.

Place yourself afterwards at a Distance twice as far from the Candle as you were at first. In this Situation the Force of the Light must be, according to the established Law, four Times less than it was at the first Distance. The Letter then cannot be read with the same Distinctness as it was at first, unless the Light be quadrupled: That is, the Law requires that the Light should grow weaker in Proportion, as the Square of the Distance increases. And this proves the Experiment to be true; for the Letter at the second Distance is then only read with the same Distinctness as at the first, when three more Candles are added to the

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single one ; or, in other Words, when the Light is quadrupled.

Considering how very easily People are apt to forget those Objects in their Absence, which made the greatest Impressions upon their Mind when present, I cannot help thinking, said the Marchioness, that this Proportion in the Squares of the Distances of Places, or rather of Times, is observed even in Love. Thus after eight Days Absence, Love becomes sixty four Times less than it was the first Day, and according to this Proportion it must soon be entirely obliterated : I fancy there will be found, especially in the present Age, very few Experiments to the contrary.

I believe, said I, that both Sexes are included in this Theorem, which seems rather to follow the Cubes of the Times, which certainly is most convenient, and requires only four Days for an entire Oblivion. But, in general, I believe we may without Scruple establish the Proportion of the Squares, for eight Days are commonly enough to cure the most vehement Passion. You alone have Power to reverse this Theorem, and make the Remembrance of you, and with that a Desire of seeing you, instead of diminishing, in-

crease according to the Squares, or rather the Cubes of the Times.

No! no! said the Marchioness, Gallantry must never destroy a Theorem. I am willing to enter into the general Rule, and shall think myself exceedingly happy if I have been able to establish any Thing fixed and constant, in an Affair so inconstant and wavering as Love.

If *Geometry*, answered I, was permitted to get some footing there, it would in a little Time produce Wonders. The Conclusions would be the most ready and elegant imaginable.

But to be serious, said she; our Conclusion in *Natural Philosophy* was, That the attractive Force of the Sun diminishes in Proportion as the Squares of the Distances increase, I suppose the attractive Force of the Planets will follow the same Proportion with regard to their Satellites.

The Satellites, answered I, which turn about any Planet, observe the same Relation between the Distances and the Times of their Revolutions, as the Planets themselves do that turn about the Sun. This is evident in Jupiter and Saturn, who have more than one Satellite, and consequently the

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the Law of their attractive Force will be the same as that in the Sun.

In the Earth, who has only one single Satellite to her Share, this is not altogether so evident. But what Reason is there why it should not be the same in one, as in the other?

If we had another Satellite revolving about our Earth at a Distance different from that of the Moon, it would discover whether the attractive Force of the Earth observes the same Law as that of the Sun, Jupiter and Saturn. This Defect however is supplied by the Bodies which we see every Day fall upon the Surface of the Earth; for we are to believe that the Force, which would make the Moon fall if she lost her Motion from West to East, is the very same that makes Bodies here below fall upon the Surface of the Earth when they are left to themselves: For since 'tis demonstrated that the Earth has an attractive Force, it is evident we must in this Force seek the Cause of Gravity, another Phænomenon, which the Vortices have been as unsuccessful in the Explication of, as in that of the planetary Motions.

If

If we could raise Bodies from the Earth to very considerable Distances (compared with that at which we stand from the Centre which is very great) we should see the Force of Gravity prodigiously diminished in them. A Man of War of a hundred Guns, for whose Formation a whole Forest was cut down, and a whole Mine exhausted, would be overfet by the slightest Breeze of a Zephyr. The famous *Stone-Henge* upon *Salisbury-Plain*, the fruitful Source of Fables both to the learned and ignorant, those *Colossian* Heaps which are held together by the Force of Gravity, would be no more than Houses built of Cards. The Velocity in the Fall of heavy Bodies would be considerably retarded. Bombs, those artificial Thunders, would not be more terrible than so many Flakes of Snow. But these Experiments are impracticable; one of the greatest Distances we can attain is *Pike Teneriff*, which is only about three Miles perpendicularly high. Besides, the Air would be too thin for Respiration, and the Cold, which must be exceedingly sharp at a greater Height, would render any Experiment fatal to the Philosopher who had the Courage to undertake it.

Nature,

Nature, replied the Marchioness, has in this Case denied us the Means of being complete *Newtonians*. She has here confined us within the Bounds of Probability. If the attractive Force observes a certain Law in the Sun, Jupiter and Saturn; why should not the same Force observe it here on our Earth?

In this Point, answered I, we have no Reason to complain; we have no need of higher Mountains, and a different Constitution of Air, in the present Case. All these Things, and the Defect of another Moon, are, as I before observed, supplied by the Bodies which fall upon the Surface of the Earth. We may compare these Bodies to the Moon herself; and thus instead of Probability we shall have Evidence, and be even in this Point good *Newtonians*.

It has been deduced from Observation, that if the Moon should lose her Motion, and fall towards the Earth, that Force which would set her a falling would be three thousand six hundred Times less than the Force which makes Bodies fall upon the Surface of the Earth. You see how well this agrees with our Principle. The Moon

Moon is distant from the Centre of the Earth (where the attractive Force chiefly resides) sixty Times as far as these Bodies. The Square of sixty is 3600, the Attraction then of the Earth to the Moon is diminished in the same Proportion as the Square of the Distance is increased ; and this is exactly agreeable to the established Law in Jupiter, Saturn and the Sun.

If the Moon should happen to fall upon the Earth, replied the Marchioness, it would present a fine and agreeable Sight to the *Newtonians* : They would certainly have neither Curiosity, Eyes, nor Calculations for any Thing else.

This might very easily happen, answered I, if every Thing was Body, as the *Cartesians* affirm ; and those ancient *Gauls*, who were apprehensive the Heavens might one Day or other fall upon their Heads, would have some Reason to fear it in the System of their own *Des Cartes* : For it has been demonstrated that if this Planet was to move in a Place absolutely filled with Matter, without the least empty Space (let this Matter be supposed ever so subtile, fluid and ætherial (her Motion from West to East would be so retarded, that it would

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foon grow weaker, and at length totally fail. And thus yielding to the Force of Gravity, she would fall precipitately from Heaven to Earth, and we should no more behold her that triform Goddess we before admired, but a Stranger banished from the most shining of her three Kingdoms, and no longer the Ornament of Heaven amidst the friendly Silence of the Night.

The other Planets would undergo the same Fate if they moved in a Plenum. These would all, some sooner, and others later, fall into the Sun, and supply that immense Vulcano with a greater Quantity of Matter. He would then reign the Sovereign of a depopulated Empire: His animating Light would shine in vain; not a single Planet would be left to partake his pleasing Influence, nor receive from him the Seasons and the Day; for both the Comets and we with our Moon should be stifled in him, if we met with any Obstacle in our ætherial Road. This would be a new Punishment to an Age fruitful of Crimes, in the System of that *English* Writer * who makes the glorious Body of

* Mr. Swinden, in his *Treatise Of the Nature and Place of Hell.*

the Sun the Mansion of Grief, and the Seat of eternal Despair.

I assure you, for my Part, I should be one of the first, continued I, who would run to see the Moon fall upon the Earth. What an agreeable Spectacle would it be to see, in Proportion as she approached to us, that Face, that Mouth and Nose, which we discover in her rather by our Imagination than our Eyes, gradually transformed into great Mountains, Vallies, Plains and the like, which must certainly fill the Vulgar with great Astonishment. Nay, even the Philosophers themselves, who can never sufficiently master those two great Enemies of Reason, Fancy and Prejudice, could not help looking on this Phenomenon with some degree of Surprise.

As she approached still nearer, said the Marchioness, should not we desery the Sighs of Lovers, Dedications to Princes, Courtiers Promises, Vials filled with the Judgment of our Sages, and all the other lost Things which *Ariosto* places there?

You have not read the Plurality of Worlds, answered I, and therefore are not capable of seeing the greatest Curiosities in that Planet; since you are not yet acquainted with

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But one Thing which I should take great Pleasure in observing, if the Moon should really happen to fall, is, what Treatment the Earth would give the Moon in going to receive her.

What, replied the Marchioness, is it a Point of Ceremony established among the Planets, that if a Satellite should fall upon it's Primary, the latter must go meet it and shorten it's Way?

This Ceremony, answered I, is founded upon mutual and reciprocal Attraction. If the Earth attracts the Moon, why should not the Moon attract the Earth? The Attraction which the Earth exercises upon the Moon is lodged in that Matter of which the Earth is composed; why then should not the Matter of which the Moon is composed exercise it's attractive Force upon the Earth, since all Matter is entirely the same, and only differently modified in different Bodies? Besides Action, as the Philosophers express it, is always equal to Reaction. Would to Heaven this Truth were not restrained to Philosophy alone. You cannot press this Table with your Finger,
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but it will be equally repressed by the Table. Thus if two little Gondulas made of Cork (in one of which is placed a Loadstone, and in the other a Piece of Iron) are set a floating upon the Water near each other, the Loadstone will run as fast towards the Iron, as the Iron does towards the Loadstone; and if either of them be hindered, that left at Liberty will spring towards the other, which could not happen unless the Iron attracted the Loadstone, as much as the Loadstone itself does the Iron, or, in short, unless their Attraction were reciprocal.

I perceive, said the Marchioness, what will be the Conclusion of all this. The Sun attracts the Planets, and consequently the Planets attract the Sun: The Secondaries attract each other, are all attracted by the Sun, and all attract him. Does not this Multiplicity, this Chaos of Attractions, perplex not only me but the System itself too?

No, Madam, answered I, it happens in this just as in the new *Geometry* (of which I was speaking to you the other Day) in which all those innumerable Orders of infinitely small Quantities, instead of perplexing,

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plexing, render it more subtile and perfect. This mutual Attraction, diffused through the Universe and all it's Parts, retains the wandering Planets in their Orbits, and connects all Bodies, the Earth and us ourselves, by strong though invifible Ties, and regulates and tempers every Motion in such a Manner, that it's Exiftence and irrefiftible Laws are every Instant apparent.

In thinking on this reciprocal Attraction, faid the Marchionefs, something comes into my Mind, which I dare not however propofe as an Objection to a Syftem which the Philofophers themfelves cannot venture to oppofe. It appears to me, that if there really was fuch a mutual Attraction, we muft fee the Effects of it in thofe Bodies which furround us, if not every Instant, at leaft very often, juft as we difcover from their Gravity the Effects of that general Attraction which the Earth exercifes upon them. When any little light Body, as a Feather for Instance, be placed near a Palace, a Hill, or any Thing whose Attraction is very ftrong, why do we not fee it prefently obey the Force which attracts it, and move, as it fhould do, towards the Palace or Hill?

When

When our Mind is possessed by a very strong Passion, answered I, what is the Reason we do not feel the weaker, unless it be that the strong Passion attracts the whole Soul, so as not to suffer the weaker to make any Impression upon it; and thus we become insensible to all the rest, which are not in themselves either light or weak? The furious Passion of *Phædra* for *Hippolytus*, in *Racine*, does not permit her to feel that strongest Passion in the fair Sex, the Desire of Beauty. Her Ornaments and her whole Dress are in that Disorder, which perhaps neither the Absence nor Death of her *Theseus* could ever have produced in them.

I comprehend you, replied the Marchioness, notwithstanding your Method of explaining this Point by Parable. The very great Attraction which Bodies feel from the Earth, if I may use the Expression, render them insensible to that of the other Bodies which surround them.

Bodies, answered I, attract only in Proportion to the Quantity of Matter they contain. I make no Scruple of using mathematical Terms to you, for to use any

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other would be an Affront to a Person who has given the Solution of a Problem.

Thus a Ball of Gold, besides many other Advantages, has a greater attractive Power than that of Wood, because it has a greater Weight; and if the first be a hundred Times heavier than the last, that is, if it contains a hundred Times greater Quantity of Matter, it will have it's attractive Power a hundred Times stronger. Now the Attraction of this great Ball upon which we stand is diffused on all Sides, and draws every Thing to it with an immense Force, and by that Means hinders us from perceiving the Effects of that particular Force, which the little Balls by which we are surrounded exercise upon each other. A Globe of the same Density with the Earth, and of a Foot Diameter, attracts any little Body placed near it's Superficies, twenty Million Times less than the Earth does. The Attraction of the highest Mountains, as that of Pike *Teneriff*, *Ararat*, or even the *Apennine*, notwithstanding the pompous Description made of it, is absolutely imperceptible. But it is not so with the Effects of the Lunar Attraction upon this vast Collection of Waters, that some Philosopher

lofopher made the first Principle of Things, which by the easy Method of Navigation joins the most distant Countries, and transports to us from another World those Balms and Aromatics, which season the *European* Entertainments.

You seem, replied the Marchioness, to have a very lively Sense of our Obligations to the Ocean, and the Advantages we receive from it. But has not the Philosopher, amidst these Entertainments, forgot the Attraction of the Moon?

The Ocean, answered I, every Day shews us the Effects of this Attraction, which extends it's Empire throughout all Nature. The ebbing and flowing of the Sea, a Phænomenon, which, in the most polished Age of *Greece*, *Alexander* the Great took as a Mark of the divine Displeasure against him, and with which the *Romans* in the Golden Age of *Julius Cesar* were but very little acquainted, is only a Consequence of that Attraction the Moon exercises upon the fluid and yielding Part of our Globe. *Chapelle* in his celebrated Voyage, that Model of polite and agreeable Wit, believed that no one but a Water-God could penetrate into it's Cause.

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the haughty Temper of his Country, and
his Compliments were not so submissive as
was necessary in addressing that Power, who
raises the Tempest by a single Nod, and
with an *I will*—silences them to a profound
Calm. The Punishment, which this arro-
gant River received for his Crime, was to
be repelled twice a Day back to his Source.
All the Rivers which flow twice a Day into
the Ocean undergo the same Fate.

But why, answered the Marchioness,
should the other Rivers who were not guil-
ty of this Gascon Behaviour, suffer the
same Punishment as the *Garonne*? If it was
permitted to make Objections to superior
Powers, I would humbly propose this to
Chapelle's Neptune.

You may make Objections equally strong,
answered I, to all the human Systems that
have been made to explain this Phænome-
non. Some affirmed the Respiration of
this vast Animal the Earth and the Sea to
be the Reason of it, others a great Gulf in
the *Northern Ocean* near *Norway* called the

Navel of the Sea, which emits a vast Quantity of Water and afterwards swallows it up again, a most fatal Circumstance both for the Fishes and Philosophy, which have the Misfortune to be plunged in it's Deeps. The ancient *Chinese*, who supposed their little Country of four Leagues Extent, to be the Universe itself, asserted that two great Nations descended from a certain Princess, the one inhabiting the Mountains, and the other the Sea Shore, had frequent Wars with each other, and this was the Reason of the Flux and Reflux, according as either of the Combatants was drove back towards the Mountains or the Sea. Such perhaps was the Infancy of Philosophy among all, even the most sagacious People. The Explication of *Des Cartes*, which was produced in a later Age of the World, is ingenious enough to render it agreeable, but not accurate enough to be true. The same *English* Philosopher, who cast an impenetrable Obscurity over Vision, by involving it in his contractile and expansive Forces, has endeavoured to involve this Phænomenon also in the same unintelligible Terms. This gloomy Fancy diffused itself like an universal Contagion over the

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the whole Face of Things, and infected the whole System of *Natural Philosophy*. According to his Opinion, the most simple and evident Method of explaining the Tides, is by ascribing their Cause to the contractive Forces of the Earth and Moon, by which the one raises and the other depresses the Water. To these he unites the expansive Force of the Sun, which, though always contrary to the contractive, yet upon this Occasion must act in Concert with that of the Moon. These unintelligible Terms, which have not so much as the Fashion to support them, can imply nothing in the Author but a vehement and vain Desire of giving his Name to a new System of Errors.

These Philosophers, said she, appear to me the Priests of *Chapelle's* Divinity: Their Explications at once discover both the Temerity and Weakness of their Philosophy.

Ours, answered I, takes Delight in Difficulties, and comes off in Triumph; amidst the Thorns we are sure at least to meet with Roses. That Portion of the Water immediately under the Moon and nearest to her, must be more strongly at-

tracted than the rest which she looks obliquely on, and which is at the greatest Distance from her. The Ocean then must flow together from all Parts, and be heaped into a Mountain of Waters, whose Summit will be under the Moon herself. The Earth itself is a little attracted by the Moon, but that Part of the Water which is directly opposite to the Part under the Moon is least attracted, because 'tis at the greatest Distance. This Part then will be as it were forsaken by the Earth, which a little follows the Attraction of the Moon, and will there form the Summit of another watry Mountain; and thus there will be two, the one totally opposite to the other. The Ocean then must swell, and in some Measure lengthen itself in that Part where the Moon is, and in the Part opposite to her, and thus from the Figure of an Apple be changed to that of a Lemon, whose Extremities will always follow the Moon in her diurnal Course; so that the Water at one Time will be depressed, and at another raised, both in the same Place. In every Part of the Ocean there will be two Tides, during the Time which the Moon employs in returning to the same Point of the Heavens.

vens. When ſhe is at the Meridian the Waters muſt be raiſed, and when ſhe ſets, depreſſed ; another Elevation, when ſhe is at the Meridian of the Antipodes, and another Depreſſion when ſhe riſes. All this muſt unavoidably happen if the whole Earth was covered with deep Waters, and they immediately obeyed the attractive Force of the Moon. But becauſe there is ſome Time neceſſary for the accumulating the Waters, and their Courſe is interrupted by Shores, Straights, Iſlands, and the like, there are ſome Irregularities in the Tides. Theſe Irregularities however are not ſo great, but twice in every twenty-five Hours, (which is nearly the Time that the Moon employs in her Return to the Meridian) we ſee the Veffels laden with the Riches of the Univerſe go up with the Tide along the Silver Waves of the *Thames*, and twice deſcend with the Reflux to go in Queſt of new Treasures. And this Advantage, which in the System of *Chapelle* was inflicted as a Punishment, all the Rivers which flow into the Ocean enjoy.

Have our *Mediterranean* Rivers, ſaid the Marchioneſs, ever offended the Moon, that they are not ſuffered to enjoy the ſame Ad-

vantage? Perhaps they have affronted her as the *Garonne* did *Neptune*.

The Straight, answered I, by which the *Mediterranean* has a Communication with the Ocean, is too narrow for so great a Sea, and is disadvantageously situated, (since it looks towards the West) to receive the great Flood of the Ocean that follows the Moon from East to West. On the other Hand the Tide, which is formed in the *Mediterranean* itself, is too much interrupted with Islands, Shores and Straights, for the Flux and Reflux to be very considerable. In the *Adriatic*, on the contrary, it is more sensible than in any other Place, because the Sea is very narrow, just as the Motion of a River is most apparent and seems most rapid when confined between the Arches of a Bridge. In our fine City founded by the Gods upon the Ocean, the Vicissitudes of the Flux and Reflux carry the fluctuating Gondolas from one Side to another, while the Gondolier sits at his Ease and singing to the agreeable Light of the Moon, teaches the Sea Nymphs the Flight of *Erminia*, or *Rinaldo's* Love.

The Changes of the Tides are still less perceptible in the *Baltic* Sea, the *Mediterranean*

near

near of the North ; for this Sea bordering upon the frozen Regions of the Pole, and very distant from the Course of the Moon, seems more adapted to Ice and Rocks, than to Warmth and Attraction.

In the Shores of the Southern and Oriental Oceans, to *Japan* and *China*, the Tide is very considerable by Reason of the Extent of the Seas ; and in our Ocean it's Effects are incredibly prodigious. There are Coasts near *Dunkirk*, where the Sea draws back for the Space of several Miles, and afterwards on a sudden returns and overflows the same Space again, alternately covering and disclosing those Sands so very suspicious to Sailors, not without sometimes disturbing the Ladies in that Country, who venture to walk upon the Margin of the Sea, whose very Shores are faithless and deceitful. These are a Sort of natural Sea Fights, where at some Parts in the Day two Armies may engage on dry Land, and at others, two Fleets, at least such as those of the Ancients were. In some Rivers the Tide rises to more than fifty Foot high, especially if the Sun and Moon act in Conjunction to render the Flood considerable, though the Moon may be regarded as Em-

press of the Ocean, the Sun however has his Share in it. Notwithstanding he is at a greater Distance from the Earth than the Moon is, yet in Return he is so much greater, that 'tis not proper he should remain idle, but lend his Part to the Production of the Tides. The rest of the heavenly Bodies have no sensible Influence in this Case, the vast Distance they are separated from us renders them too small. When the Moon is in her Quadratures, the Tides are less than at any other Times in the Month. The Reason of this is, because the attractive Forces of the Sun and Moon crossing each other, are as contrary as is possible to the swelling of the Sea in the same Situation.

On the other Hand, when the Moon is new or full, she is in the same direct Line with the Sun in respect to the Earth, their Forces are united, and then the Tides are highest. It is to be observed however, that the Motion begun in the Waters and retained for some Time within them, must be some Days after the new or full Moon, before it produces the greatest raising of the Sea. So in Summer, the Heat of Mid-day that remains in the Air, being added
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to the following Heat, less intense in itself, is the Reason why we have not so great need of the Assistance of the Fan to supply us with fresh Air at Noon itself, as we have some Hours after. The greatest of all the Tides happens at the new or full Moon of the Equinoxes; for besides the Conjunction of the Solar and Lunar Force, the Waters in this Case acquire a greater Agitation; but because the Sun (notwithstanding our freezing) is nearer to the Earth in Winter than in Summer, these great Tides do not happen at the precise Time of the Equinoxes, but a little before the Vernal, and something later than the Autumnal, that is, in the Month of *February* and *October*. In Mercury, Venus, and Mars, the Tides are governed by the Sun alone, though they must be almost insensible in Mars, because that Planet is at so great a Distance from him. In Jupiter and Saturn the Distance from the Sun is so very great, that he can have absolutely no Influence over the Tides. They will confound each other according to the Caprice of the Satellites, the great Number of which will render them very irregular. If we knew the Time of Saturn's Rotation as we do that

of Jupiter's, and were as well acquainted with the Geography of both, and the Quantity of Matter contained in their Moons, as we are with their Distances and Revolutions, we might conjecture the Quantity and Period of their Tides, and send Tables of them to their Pilots. Thus are we again transported by Attraction into Heaven, to vast and remote Worlds where this powerful Quality holds it's most conspicuous and manifest Seat.

By the Help of this, replied the Marchioness, we can travel thousands of Miles in an Instant, and are well recompensed by innumerable great and shining Truths.

A *French* Author, I answered, a zealous Propagator of this System, like us transported by Attraction to these distant Worlds, thinks with great Probability, that the Moons of Jupiter and Saturn as well as ours had once been Comets, which passing near enough to these Planets to remain confined within the Sphere of their Attraction, were constrained to revolve round them, and thus degraded from the Rank of primary to that of secondary Planets. Saturn has obtained so advantageous a Situation, as to make him the most happy
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in the Number of his Conquests. For the same Reason he was able to acquire a fine Ring that incompasses his Body, and which was formerly a Comet that unhappily passed too near him.

This Saturn, replied the Marchioness, must be very terrible to the Comets that approach a little too close to him. He must be the same to them as the *Cabo tormentoso*, to which Avarice afterwards gave the Name of *Good Hope* was to the *Portugueze*. It must, I fancy, have been a very agreeable Sight to see Saturn, at once adorn and enrich himself with a splendid Ring, while the poor Comet was forced to pursue it's Journey, spoiled of the Honour of it's shining Train.

He robbed it of nothing, answered I, but what it enjoyed at another's Expence, according to the Supposition of another *French* Author, who assures us that the Comet in crossing the Atmosphere of the Sun, had from thence stolen it's Tail. But the *Newtonian* Opinion is, that the Tails of Comets are formed and composed of certain Vapours arising from the Comets themselves when they are near the Sun.

Is it not a very great Advantage, replied the Marchioness, to be possessed of a System that supplies even the Imagination with the most pleasing Amusement, by those strange and surprising Events which it renders possible?

And all this, answered I, only by the Force that among us makes a Stone fall to the Earth.

This Attraction, said she, appears to be the same in the Hand of Nature, as the Subject of a Composition in that of a skilful Musician. Be it never so simple, yet when he undertakes it he will diversify it a thousand Ways, and make it appear every Moment new; in short, he will find enough in it to form the most harmonious Concert in the World.

Nature, continued I, wants no other Subject at once to regulate and vary those innumerable and vast planetary Systems, which probably revolve round the fixed Stars, those luminous and attractive Suns that cheer the Night, and which we debase by giving them the Names of our miserable Heroes.

But why should these Heroes, said the Marchioness, remain unmoved and fixt?

If

If they have a mutual Attraction, how comes it to pass that they do not approach each other, and run all together? You have perhaps some other Parable ready, which only waited till I should propose a Difficulty.

No, Madam, answered I, unless you take it for a Parable when I tell you that this would exactly happen, if the Number of those Suns was not infinite. Those which are upon the Superficies of this immense Sphere of Suns, would be united to those next them, because they would not have any Thing to attract them a contrary Way, and by that Means keep them in their Orbits. And thus these successively running into those next them, and these last into others, they would be all heaped together. By this Means in a little Time, there would be in the whole Universe only one Sun of an enormous Size. But what is the Number of these Suns? What are the Limits of their Sphere? Is not the Centre of it throughout, and the Circumference in no Place? The Difficulty you have moved would be alone sufficient to induce us to multiply the Stars *ad infinitum*, even if we had not a thousand Reasons besides.

I am

I am quite lost, replied the Marchioness, in this Infinity of Suns and planetary Worlds; pray let us return to our own.

We are possessed of a System capable of diversifying it to Infinity, if we were so fond of Infinity as to desire it.

And a System, answered I, which predicts and gives a Reason for the very smallest Irregularities that can happen. After Attraction and it's Laws were established, how sublime a Geometry was requisite to find out what Path the Planets must keep in the Spaces of Heaven, and how much more sublime still, to foresee exactly how much they would deviate from that Path, in the Constitution of the present System? The Vastness of the Object renders general Rules difficult, and the Niceness of the Variations renders any Exceptions still more difficult. The Sun who was esteemed immoveable in the Centre of the System, and imagined himself exempt from any Irregularity, is found however to be subject to it; for the Attraction between Bodies is always mutual, and every Cause must have a correspondent Effect proportioned to it's Activity. As the Planets and Sun reciprocally attract each other, he must be sensible

of

of their Force; so that to speak with the utmost Rigour, he continually changes his, as they vary their Situation with Respect to him.

After all our Speculations then, replied the Marchioness, to prove the Immoveability of the Sun, we are at last reduced to make him move again. Had it not been better, continued she, with a certain malicious Smile, to adhere to the common Opinion without giving ourselves all this Trouble? Do not you act like those Persons, who after employing their Reason to divest themselves of popular Prejudices, are afterwards obliged to have Recourse to the same Reason to resume them, if they have an Inclination to live and converse with their Fellow Mortals?

Our Case, answered I, is extremely different. The Question then was to make the Sun revolve about the Earth with such a Motion, as to run a Million and a half of Miles in one Day. But at present, the Earth herself continues to revolve about the Sun, and he has no other Employment than to approach or recede a little sometimes towards one, and sometimes towards another Side of the common Centre of the whole

whole System. This Motion is insensible in Astronomy, and in Fact is only a mathematical Subtilty, with which I thought myself obliged to make you acquainted. If the Planets were all on one Side, you are sensible that their united Forces must act upon him with the greatest possible Strength, in Order to draw him back to themselves, and make him recede from the Centre of the System: They would not however attract him, considering the Enormity of his Bulk, any more than one of his Diameters.

I am very willingly convinced of my Error, said she. The Sun, who, notwithstanding his vast Size, is subject to the general Force of Gravity, may serve for an Example to great Kings, whom neither the Extent of their Fortune, nor the Superiority of their Station, can ever exempt from an Observation of the universal Laws of Humanity.

Our Moon, continued I, is at present subjected by Attraction, to the minutest and most exact Calculations of Astronomers. Her very Irregularities, her Caprices are reduced to certain and constant Rules. Comets, those Enemies of Systems, who made still greater Resistance to the
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Power of Numbers than the Moon herself, are at Length obliged to revolve about the Sun. And though their Orbits are much more oblong than those of the Planets, yet they observe exactly the same Laws. By Observations made upon their Appearances, Philosophers have assigned what Orbits the Comets must run in this System, and these in Fact are the Orbits which they really have run, almost with the same Exactness as the other Planets, notwithstanding the imperfect Observations left us by the Ancients concerning Comets, the Moderns have ventured to predict the Return of some of them, in the same Manner as they do Eclipses. And indeed, what is there which this System might not authorize? A *Titian* could easily judge of a Picture from a rough Draught. The Prophecy of that Ancient is now fully accomplished, who even in his Time foresaw that Posterity would calculate the Periods and predict the Returns of these Bodies, these eternal Monuments of the Ignorance and Weakness of human Nature. It is expected that the Comet which appeared in 1658, will return twenty three Years hence, and I hope we may flatter ourselves we shall observe it together,

together, you still young, and I not very old. You shall be the *Urania* to give a right Direction to my Telescope.

What a Vicissitude of Things, replied the Marchioness, is there in this System? I am metamorphosed into a *Urania*, and supposed to be young at a Time when it becomes unpolite to talk about Years, and the Non-appearance of a Comet rendered more fatal than it's Appearance!

It will appear too soon, answered I, to put us in Remembrance of our past Time, and our Attraction.

In this Case, replied she, we may express ourselves contrary to the common saying,

'Tis Expectation makes a Blessing dear.

Upon the present Establishment of Rules in Astronomy, it is a great Happiness to understand it thoroughly, as it's Professors need not fear to expect any Thing in vain, and how great a Pleasure do they owe to this System, which gives them a full Power over every thing in that Heaven, which the is Object of their Projects and Desires.

Nothing

Nothing, answered I, was a greater Curiosity to Astronomers, or more glorious for the *Newtonian* System, than the Conjunction of Jupiter and Saturn, which happened in the Beginning of the present Age, an Age so fertile in the most surprising Events. These two great Planets were to approach each other, which the vast Extent of their Orbits, and the Time employed in describing those Orbits, had not very often suffered them to do. If it ever could be hoped to see the Effects of this mutual Attraction in the Disturbance and Alterations in the Motions of the Planets, it was upon this Occasion, when the two most powerful in the whole solar System approached each other, at a Distance however of three hundred and fifty Million of Miles. This was an Observation in great, as decisive for the *Newtonian* celestial System, as the Experiments of refracting the coloured Rays with a second Prism, (in Order to prove whether Colour was a Modification of Light or no) was in little. The Curiosity in this Affair was so much the greater, because the *Newtonian* System was then in it's Infancy, and Time which gives Strength to Truth, and in which Error vanishes away,

away, had not yet decided any Thing to the World it it's Favour. The Disturbance which Jupiter, the greatest of all the Planets occasioned in the Motions of Saturn, and that which this Planet reciprocally exercised upon the Satellites of Jupiter, were so considerable, that they could not escape the Observations and Testimony of Astronomers, even those who were the least inclined to adopt the System, whom a Difference of Opinion from the Wagers held against it, might easily induce to regard this Phænomenon in a very superficial Manner. And Sir *Isaac Newton* had the Consolation of dragging out of the Mouth, I may say of his very Enemies, a strong and solemn Confirmation of his System. What are the Triumphs of the *Cæsars* and *Alexanders* (those miserable Conquerors who overturned two Particles of this Globe) when compared to the philosophical Triumph of him, who first discovered the vast Extent of the Universe.

Astronomy, said the Marchioness, has by this Triumph amply rewarded Sir *Isaac Newton* for defending it so well in the Affair of total Eclipses. This mutual Assistance, this Commerce, if I may use the Expression

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Expression of Truth, must certainly be a very great Honour to the Sciences.

This Commerce, answered I, was never more evidently seen than in Attraction. We may affirm that every Science with a Sort of Emulation contributes to confirm this Truth, just as the whole World anciently did to the Grandeur of *Rome*. Tho' I told you that the Effects of Attraction are more remarkable in the Heavens than any where else, yet it is also very evident in all *Natural Philosophy*, *Hydrostatics*, *Chemistry* and *Anatomy* itself. Mr. *Muscembrook* (who even in Philosophy presents the Character of a true Republican) confesses with that Freedom that becomes a Member of the *Belgic State*, that for the Space of many Years spent in the greatest Variety of Experiments, he has observed in all Bodies certain Motions and Effects, which could not be explained or understood by Means of the external Pressure of any ambient Fluid: But that Nature proclaims aloud a Law infused in Bodies, by which they are attracted without a Dependence upon Impulsion. Chemical Fermentations, the Hardness of Bodies, the round Figure of Drops of Water, and of the Earth itself,

self, the Separation of the Juices in the human Body, the Suction of Water by Sponges, it's Ascent in those Tubes, which from their extreme Smallness are called Capillary, and a thousand other Things, are incontestable Arguments for this Attraction. I believe, that after so many repeated Proofs, you will permit me to introduce it triumphantly into *Optics*, in Order to explain the Effects which depend on this mutual Attraction between Light and Bodies.

It would be very extraordinary, said she, if I should refuse to admit the mutual Attraction of Light and Bodies, after I have seen the Sun and Saturn attract each other at so enormous a Distance.

Not to say any Thing more of Diffraction, answered I, is not Refraction an Effect of this attractive Power? Does it not arise from hence, that the Mediums through which the Light passes, are indued with this Force in a greater or less Degree, according to the greater or less Density of the Medium wanting, and won't this Force be superior to Gravitation? Otherwise the immense Force of the Earth which attracts every Thing to herself, would render it impossible

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neriff, to attract the smallest Ray of Light.

While the Light passes through the
same Medium, because it is equally at-
tracted on all Sides, it will not decline to
any, but move forward according to that
Direction it received from the Sun or any
other luminous Body: If in it's Way it
meets with another Medium of a greater
Force (such as Glass for Example compared
to Air) must it not decline towards this
Medium and immerse into it, approaching
more or less to a Perpendicular as the At-
traction of the new Medium is more or less
powerful? In going out of Glass into Air,
the Light is again attracted by the Air and
the Glass, but because the Force of the
Glass is greater than that of the Air, the
Light will remain behind the Surface of
the Glass from whence it goes out, or be-
hind that of the Air into which it enters,
and which immediately touches the Glas's
itself. Thus you see how easily by the
help of Attraction is explained a Phænc-
menon, which *Des Cartes* could not account
for, unless by supposing that Light could
with greater Facility pass through dense
than rare Mediums; which is in other
Words

Words saying, that what makes the greatest Resistance to all other Bodies, must by some other Privilege of which I am ignorant, make the least Resistance to this. It is surprising to see how all that Experiments have discovered to happen in Refractions, are geometrically deduced from this Explication of the *Newtonian* Philosophy.

To me, replied the Marchioness, who can't enter into the Sanctuary of Geometry, it seems a sufficient Proof that as the attractive Force is greater in Proportion to the Density of the Medium, the Refraction in that Case must be proportionably greater.

The *Dutch*, answered I, have found it to be much greater in *Nova Zembla*, than here among us. The Air is extremely cold, and consequently dense in this Country, the Habitation of white Bears, and some Europeans, the miserable Victims of the Avarice or Curiosity of their Species. By the Help of this very great Refraction they had the Pleasure of being recreated with the Sight of the Sun after his long Absence, many Days before the Science of Cosmography had allowed that he could appear, and the Density of the Air, which

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generally oppresses and damps the Spirits, served in this Retreat of Misery and Darkness to revive their Imagination by a premature Return of unexpected Light.

We may at present hope for more exact Observations upon the Density of the Air, and the Refractions of this Climate, which have never yet been examined by philosophical Eyes. A learned Company is now setting Sail from *France* to the *Botbnic Gulph*, and another to *Peru*, in order by their united Observations to determine, if possible, the true Figure of the Earth, and animated by the Love of Science, have the Resolution to change the Gardens and the delightful Seats of Pleasure in their own Country, for the frozen Rocks and Deserts of *Lapland*.

In North *America* the Colds are incomparably more sharp than in *Europe*, at the same Distance from the Pole. There are in those Seas Mountains of Ice of the same Date perhaps as the World, among which are sometimes found Ships at full Sail as motionless as upon dry Land.

Doctor *Halley*, whom the *English* Nation regards with the highest Respect as the Friend and Companion of Sir *Isaac Newton*, and whose Thoughts are employed on

no Objects that are little or trifling, believes that these Countries were once perhaps nearer the Pole than they at present are ; that a Comet by giving a Shock to the Earth altered their Situation, and by this Means set them at a greater Distance. But that notwithstanding this, the great Magazine of Ice formed before this terrible Shock still remains ; nor has the Heat of following Ages ever been able to melt it. Hence proceed the sharp Colds and a stronger Refraction caused by them. Certain *English* Sailors, who above a Century ago endeavoured without Success to find in North *America* a Passage to the Southern Sea, were obliged to spend the Winter in an Island very little more North than *London*. Every Thing there was transformed to Ice, the House they had built, the Sea, the Ship, and even themselves. They were obliged to cut the most spirituous Wine with a Hatchet, and the Refraction was so strong, that they observed the rising Moon of an oval Figure extremely long, and the Sun when at the Horizon to be twice as big in Breadth as in Length. The Air was sometimes so very clear in the Depth of that severe Winter, that they discovered more

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Stars by two Thirds than are usually seen, and the Milky Way appeared evidently to the naked Eye a Collection of Stars. Thus in these Countries there would have been no need of a *Democritus* to conjecture it among the Dreams of the ancient Philosophers, nor a *Galileo* to verify it by the Assistance of the Telescope.

From a great Number of Experiments made in *England*, it evidently appears, that the refractive Power of the Air increases in Proportion to it's Density, which is true likewise in other Mediums which refract the Light, but however with some Exceptions. Air, Water and Glass sensibly observe this Proportion. But oleaginous and sulphureous Liquors, and which consequently are combustible, have a greater Refraction than Liquors of another Nature, even if they are more dense. Oil which is less dense than Water, as appears by it's swimming upon it, has however a greater Force in refracting the Light.

Alas! interrupted the Marchioness, I am a great Enemy to Exceptions, and I have a most mortal Aversion to the *but* in Conversation. Every one who takes it into his Head to rail against our Sex before

our very Faces, will doubtless except, with a constrained *but*, her who has the Misfortune to be present. Satire, so agreeable to the Malignity of our Mind, becomes cold with these Exceptions, our Self-love is not sufficiently flattered, and Truth loses too much when it becomes less general.

Exceptions of this Sort, answered I, are properly only new Truths which arise from the Discovery of many Causes, which joined together generally concur to produce a certain Effect. This greater Refraction in a less dense Medium, arises from another particular Correspondence between these Liquors and Light. It acts more upon them than upon any other Sort, by agitating, warming, and inflaming them more easily. It is just then, on the other Hand, that these in Return should act more upon the Light than other Mediums do, by breaking and refracting it in a greater Degree. May we not conclude from hence, that this Force resides chiefly in the sulphureous Parts of Bodies? For this Reason boiling Water, in which these Parts are more disengaged, has a greater refractive Force than cold Water. In general, Warmth and Rubbing augment the attractive

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tractive Force which is in Bodies, or make it appear in a particular Manner. Amber, all Sorts of pellucid Gems, Glass, Hair, and many other Things when they are rubbed, discover the Force called Electrical, and which is communicated to other Bodies, carried to incredible Distances, and whose Effects are surprising beyond all Belief. If a Tube of Glass be rubbed till it gets hot, it will attract light Bodies, as Leaves of Gold or Cotton, and afterwards drive them at a Distance. It will raise a Sort of Tempest in a Heap of little Pieces of burnt Paper by attracting, and then tumultuously repelling them from itself. In short, this Force is a Species of magic Wand, that communicates and awakens a Power in Bodies, which had before lain dormant and inactive. A Ball of Ivory fastened to a Cord of nine hundred or a thousand Foot long, acquires the same Power of Attraction and Repulsion, if the electrical Tube be applied to the other End of the Cord a thousand Foot distant.

You had very great Reason, replied the Marchioness, to call this Tube a Sort of magic Wand, for it really produces incomprehensible Effects. At least, it is a Mystery

to me that it should with such Rapidity draw the little Bodies to itself, and afterwards with a Sort of Disdain remove and drive them away.

Observation, answered I, which has hitherto been our Guide and a Sort of *Ariadne's* Clue, in the intricate Labyrinth of *Natural Philosophy*, will continue to give us the same Assistance in that little Way we have yet to go. It has conducted us to the Discovery of new Properties in *Light* and *Colours*, which have opened a new Scene of *Optics* to Philosophy. It has conducted us to the Discovery of Attraction in the most secret Retreats of Bodies; which is likewise a new and surprising Quality of Matter, by which all *Natural Philosophy* is changed and renewed; and now this faithful Guide leads us to Repulsion, whose Effects in Nature are no less considerable and surprising. Are we not to impute it to this Force, that Flies are able to walk upon the Water without wetting their Legs, and that the Particles, which fly off from Bodies, by Means of Heat or Fermentation, are set at so great a Distance from each other, as to possess an infinitely greater Space than they did at first? The Air after
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being compressed may be dilated to such a Degree, as to possess a Space more than eight hundred twenty six thousand Times greater than it did when compressed, and this without being heated, which would make it dilate itself still more. That you may understand this Force has no less Influence in Heaven than Earth, the famous Comet of 1682 approached so close to the Sun, that it was heated two thousand Times more than a red hot Iron. The Vapours arising from it, and cast at a Distance from each other by the repulsive Force, adorned it with so formidable a Tail, that it took up in Heaven the Length of eighty Million *English* Miles. It would have been very bad for us to have been near, and involved in it, for instead of gaining a Ring or another Moon, we should have been calcined and burnt to Ashes like a little Stone in the Focus of a burning Glass. Some Persons so taken up with the Phantoms of the uncertain *Future*, as not to see the fugitive *Present*, expect that one Day some Comet will cause the universal Conflagration of this Globe. Comets have anciently perhaps produced a Deluge, have struck against the Earth and overset every Thing

in it, and who knows but one Time or other they may bring a Conflagration upon it, after which laying aside it's old Spoils like the Snake, it may again grow young and be renewed, and our great Theatre change both it's Scenes and Actors.

The *Present*, replied she, is so various and agreeable as it now stands, that I am greatly deceived if it may not divert us as yet a long Time without any Change.

But perhaps it is to these Comets that we are obliged for one of the finest Changes, and what we every Day enjoy. They are perhaps the ingenious Mechanists that have rendered our Theatre capable of being turned round like that of *Curio*, so famous in Antiquity, where the *Roman* People, the Conqueror of the World, the Race of Heroes, and the Portion granted to Mankind by the immortal Gods, sat upon a frail Machine, in which they could not even applaud their publick Shews without Danger. We at present perhaps owe to some Comet (without apprehending any calamitous Accident) the Rotation of our Earth, the perpetual and constant Succession of Light and Shadow; in short, the pleasing Variety of Day and Night. One
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of these perhaps by giving us a Shock, has occasioned this Motion in us as well as the other Planets, which are discovered to be indued with it. Before this we had, like the cold Inhabitants of the *Pole*, six Months Day and six Months Night, but without gaining like them either a strong Refraction or a long Twilight to anticipate and prolong our Day. A little Moon-light would from Time to Time have faintly illuminated that long and melancholy Darkeness. What *Optics*, what Colours could we ever have had for six continued Months, unless the Comet with it's Shock had lent us it's Assistances.

Since every Thing, replied the Marchioness, stands well at present, Heaven guard us for the future from the Proximity of any one of them, from the Shocks, the Conflagrations and the Deluge with which they menace us, and from that repulsive Force that renders them so very formidable. But are not these the Riddles as well as Terrors of *Natural Philosophy*, that the same Bodies should be both attracted and repelled?

I do not know, answered I, after some Pause, whether I ought to introduce you

any farther into the Sanctuary of the *Newtonian* Philosophy. There are in this certain Myſteries ſtill deeper and more ſublime than thoſe to which you have already been admitted. You ſhould now invoke thoſe Spirits the firſt-born Sons of Light, the Guardians of thoſe ſecret Truths which they imparted to our Philoſopher, that they would ſuffer me to diſcover to you Things concealed from the Sight of Mortals, and deeply immerſed in a gloomy Miſt and the moſt profound Night. You muſt now entirely divest yourſelf of thoſe few Remains of Profaneneſs which may ſtill attend you. Tell me, Madam, what Courage do you feel for Truth?

The ſame, answered ſhe, that a brave Soldier feels to follow his Captain wherever Valour calls. I follow you without Fear wherever Truths leads the Way.

You appear, answered I, to think it a Riddle in Philoſophy, and indeed with ſome Reaſon, that the ſame Bodies ſhould be both attracted and repelled. But would not the Riddle be ſtill greater, if I tell you that theſe two contrary Forces, the attractive and repulſive are of the ſame Nature, and in ſhort, 'tis only the ſame Force
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The Marchionefs at this could scarce forbear laughing. What, said ſhe, do you call the attractive and repulſive Force the ſame Thing ? One acts directly contrary to the other, ſince the firſt attracts and the laſt repels. Are theſe thoſe ſublime Myſteries in *Natural Philoſophy* of which you hardly thought me worthy, and which you have introduced with ſo much Apparatus ? Does not all this greatly reſemble the Phyſician in *Moliere*, who affirmed roaſt and boiled to be ſame Thing ?

What, answered I, do you ridicule the moſt ſacred Things in *Natural Philoſophy*, and of whoſe Uſe you are yet ignorant ? What a Spirit of Profaneneſs ſtill remains in you ! But you ſhall quickly be puniſhed. Remember the Concluſion, which you yourſelf juſt now deduced from that very Attraction you made ſo great a Difficulty to admit. Ladies, of all Perſons, have leaſt Reaſon to be ſurprized, that the ſame Thing ſhould produce contrary Effects. Do not the higheſt Reſerve, and the moſt evident partial Fondneſs towards any Perſon, often proceed from the ſame Principle, and teach

Connoisseurs to draw the same Conclusion from them? The Sun hardens and softens, according to the different Circumstances in which he exercises his Heat. This Truth is no less evident in the most noisy Affairs of human Life, than in the Phænomena of Gallantry and *Natural Philosophy*. The same Thirst of leaving an empty Name, and living in the imaginary Breath of Posterity, burnt the Temple at *Ephesus* in *Asia*, and precipitated a *Roman* and his Horse into an open Gulf in the midst of the *Forum* at *Rome*. The same Passion made *Curtius* an Hero, and *Erostratus* an Incendiary. There are certain Things which to the Vulgar, nay even to the philosophical Vulgar, may appear as evident Contradictions in the same Man, whom some upon that Account have imagined to be double (as others did the Governor of the Universe) so then what the one willed the other disapproved; but are not these Contradictions the necessary Consequences of the same Passion and the same Motives? Thus the very same Cause by which Bodies are attracted may in some Circumstances repel them. There are found certain Analogies between these two Forces, which give us great Reason to

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conclude, that they are in Reality only the same Force which produces different Effects. It is generally found that where the attractive Force is weak, the repulsive too is weak, and where the one is strong, the other is strong also. Refraction which depends on one of these two Forces, and Reflexion on the other, are both effected where there is a Surface that separates two Bodies of different Density. For while the Rays proceed in the same Medium, and don't meet with one of a different Density, they are neither reflected nor refracted. Those Rays which are most refrangible, are likewise more easily reflected than the rest. In Bodies by which the Light is more refracted, 'tis likewise more strongly reflected. And in general, where the attractive Force is greatest, the reflective and repulsive is greatest also. Diamonds, which refract the Light very strongly, give it in Proportion a stronger Reflexion. Hence proceeds the Vivacity of their Colours and their fine sparkling Lustre.

These Analogies, replied the Marchioness, are very pretty and very good, and so are the Examples by which you introduced them, and very strongly reproach
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my Rashness. I am heartily penitent for my Fault in laughing when I should have admired, and despising what I ought to have regarded with Veneration. But did you not tell me, that Reflexion happens when Light meets with the solid Parts of Bodies, and is from thence repelled? This Explication seemed very intelligible to me, and perhaps more so than what you at present intimate.

It is *Des Cartes*, Madam, who gave you this Explication, and not I, therefore you may be in some Apprehensions about it. *A Propos* to *Des Cartes*, an ingenious Author gives a very useful Piece of Advice, that in Philosophy we should be as diffident of what we imagine ourselves to understand very easily, as of what we don't understand at all. If Reflexion was the Consequence of an Encounter between Light and the solid Parts of Bodies (as you so clearly understand it ought to be) do you know what an Inconveniency would from thence arise in Nature, you would have no longer Toilette or Looking-glasses? A Surface, however smooth and polished it may be, is however full of Protuberances and sensible Irregularities discovered by a

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Microscope. Imagine all Bodies which you believe the most smooth and polished, to be like Water when it is ruffled by the Wind. The Light must be reflected from all Bodies irregularly as 'tis from Water thus ruffled, and could never be sent back with that Regularity as is necessary for you to see yourself in a Looking-glass. Is not this paying a great Price for your fine Explication ?

Is it really true, answered she, that 'twill cost so dear? Perhaps you put me into a greater Terror than the Danger deserves. Is it not possible that these Irregularities in the Surfaces of Glasses, though sensible to the Microscope, may yet be insensible to the Light ?

You are grown extremely difficult, Madam, of late, answered I. The Protuberances and Cavities in the most smooth and polished Glasses, are when compared to a Particle of Light, what the *Alps* or *Pyrenees* would be in respect of a Tennis-ball. The Irregularities of a Looking-glass are discoverable by common Microscopes, but there is no Microscope so perfect as to shew the Pores of a Diamond, through which the Light however passes very copiously.

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It would be a terrible Circumstance for us, if the Particles of Light were not almost infinitely small. The Force of Bodies is reckoned from the Quantity of Matter that they contain, which is called the Mass, and from their Velocity; the greater therefore their Mass and Velocity, the greater is their Force. The Particles of Light have an incredible Velocity, for they come from the Sun to the Earth in about eight Minutes, and thus in eight Minutes they run through a Space of eighty one Million of Miles. Their Velocity then being so extremely great as to exceed more than ten Million Times that of the swiftest *English* Horses, their Mass must be almost infinitely small, or else a single Particle of Light, instead of animating and reviving all Nature by it's Appearance, would produce upon our Earth the most terrible Effects of a Cannon.

The good Effects, answered the Marchioness, of that Diffidence we ought to shew to Men, extend likewise to Philosophers; for by this Means the one gives greater Proofs of what we desire should be true, and the other of what really is so. I will for the future be very careful not to believe you too hastily.

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For this Time at least, answered I, you can't accuse yourself of too much Credulity. It will never burthen your Conscience, that you have not had sufficient Arguments to believe, that Reflexion is not made by the meeting of Light with the solid Parts of Bodies. For besides the great Absurdities which would arise if this Supposition were true, Observation informs us, that Light, transmitted through a Piece of Glass, suffers a stronger Reflexion at going out of the Glass than it did at entering into it. Now how is it possible that Light should find more solid Parts in the Air than in the Glass itself, to occasion this stronger Reflexion? Besides, if Water or Oil be placed immediately behind the Glass, the Reflexion becomes weaker. Will the Light find fewer solid Parts in Water or Oil, than in Air? Lastly, if the Air which is behind the Glass be taken away by an Instrument made for that Purpose, the Reflexion will be much stronger than 'twas before the Air was removed. Will you say that Light meets with a greater Number of solid Parts in a Vacuum than in the Air?

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Heaven forbid that I should say it, replied the Marchioness, I will make rather the repulsive Force to be the Cause of Reflexion.

In these Cases, answered I, 'tis not the repulsive but the attractive Force. When a Ray goes out of the Glass into Air, it is attracted by the Air and the Glass; hence that Part of it which was nearest the Glass, returns back as if it had been reflected, if the Air be entirely taken away, this Part being extremely attracted by the Glass, and hardly any Thing by what remains after the Air is removed, it returns back again almost entire. But if Water or Oil (which attract the Ray much more strongly than the Air does) be placed behind the Glass, a less Part of the Ray will return back than there did while the Air remained. Lastly, when the Forces of the two Mediums are balanced, as for Instance, when a Liquor be applied to the Glass of pretty near the same Density, or another Piece of Glass, the Ray must pass entire, and there will be no Reflexion.

In general, we may affirm that the attractive Force is the Cause of the Reflexion of the Rays, when the Light passes from a dense into a rare Medium; and

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and the repulsive, when it passes from a rare to a dense. In both Cases, since the attractive and repulsive Force are propagated at some Distance from Bodies, the Light is reflected notwithstanding it's Distance from the reflecting Body. Just as when it begins to be refracted, 'tis somewhat distant from the refracting Medium, in the same Manner as 'tis from the Extremity of Bodies when passing near them, 'tis turned out of his direct Path and curved by Diffraction. Hence you see that solid Parts and *Des Cartes's* Explication have less to do with Reflexion than ever.

Poor *Des Cartes*, continued she, is attacked in his very last Retrenchments. There is nothing wanting to complete his Overthrow, but for us to assert, that as Light is not reflected from solid Parts, so neither is it transmitted from the Pores of Bodies, and thus he may return back like that momentaneous *Alexander* of the North, who after the most rapid and noisy Victories, at Length lost the best Part of his own Dominions. In Order to deny him every Thing, and give him Leave to return Home as soon as he pleases, we will at least deny that the Quantity or Magnitude

tude of the Pores in Bodies contributes any Thing to their Transparency. It is proved on the contrary, that if the Pores of a Body, for Instance Paper, be filled with Water or Oil, it loses it's Opacity and becomes transparent; whereas if the Pores in a Body be multiplied, as when Glass is reduced to Powder, it loses it's Transparency and becomes opaque. It is in Homogeneity we are to seek the Cause of Transparency. If there be many Pores in a Body, and these be filled with a Matter different from that of the Body itself, the Light will meet with a thousand Reflexions and Refractions in the internal Parts, and thus it will be utterly extinguished. The Air ceases to be transparent when 'tis cloudy, though 'tis then lighter than when 'tis clear, and consequently more porous. It's Opacity can arise from no other Cause, but that 'tis at that Time heterogeneous, which makes the Rays that pass through it suffer innumerable Reflexions and Refractions, by which Means they are very soon stifled and extinguished. Thus the Froth of *Champagne* is opaque, though much more porous and lighter than the Wine itself. This seems to furnish us with an Argument to
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infer, that the Heavens can't be filled with Matter however rare it be supposed, even if all contained within the vast Orb of Saturn, and though it's Pores should be as small as you can possibly conceive, might, after being perfectly united so as to leave no empty Space, be grasped in one Hand.

What strange Relation is this you tell me, replied the Marchioness, is the *Newtonian* Philosophy some Golden Fleece, which we must not undertake the Conquest of, till we have passed through a thousand strange Portents, and subdued a thousand Monsters of Imagination.

Do you believe, answered I, that Gold, the precious Substance for which Mankind do and suffer so much, and for which we feel the greatest Thirst when we ought to be most satisfied; Gold, I say, and Diamonds themselves, the most shining Work of Nature, notwithstanding their great Weight and Gravity, contain a great Quantity of Matter? It will appear strange when I tell you, how very little that Quantity really is, when compared to that Vacuum between the Parts, and which to our deluded Eye seems perfectly full. The solid Parts contained in a Piece of Glass, are no
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more considered with Regard to it's Extent, than a Grain of Sand to the terraqueous Globe. It is very suprising how little solid Matter there is in the World, and with how few Materials, if I may use that Expression, 'tis built. Perhaps if you knew the Truth, you would be afraid you walked upon Cotton, and were in Danger of crushing it under your Feet, even if they were as light as those of the swift *Camilla*, or of that modern Dancer, whose Steps it would tire the Wings of Love to pursue, and from whom the amorous *Zephir* is not nimble enough to snatch a Kiss, unless he waits till she has finished her Dance. Now if the Matter of the Heavens be imagined unconceivably rare and subtile, yet the Light which, notwithstanding it's prodigious Velocity, employs according to the last Calculations, six Years in coming from the Stars to us, must be entirely extinguished by the Multiplicity of Reflections and Refractions which it must suffer in that immense Passage; just as a numerous and flourishing Army in a long March, must decrease and perish by the Fatigues and Obstacles it meets upon the Road.

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I see with Pleasure, said the Marchioness, how the Properties of our Light conduct us to empty Heaven, and after having set the Earth in Motion clears the Way for it.

The Diffractions too, answered I, which the Light would suffer from the Particles of this celestial Matter, would contribute not a little to extinguish it, in the same Manner as they would do in Bodies that are very porous and heterogeneous. It is surprising, that in the Notes which *Perrault* wrote upon *Vitruvius*, he seems, if I remember right, to have had some faint Notion of this Truth. Rarefaction, said he, (that is, a Distance of Parts) renders Bodies opaque, because these, which were at first homogeneous, when rarified become heterogeneous.

It seems much more surprising, said the Marchioness, that any Person could clearly see and demonstrate, that two Things so very opposite as Reflexion and Refraction, should yet arise from the same Cause; this I must confess will always be a Wonder to me.

The Facility, answered I, and the Obstacles which the Light meets in passing out
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of one Medium into another, are almost in the same Case. Perhaps an exceedingly subtile Fluid diffused in the Confines of the Mediums extremely quick in it's Vibrations, and in which the Light by Percussion excites an undulating and tremulous Motion (as a Stone does in Water, or a Voice in the Air) is the Cause of both the Facility and Obstacles in Question. Thus if the Light happens to be in the Concavity of the Waves of this Fluid, it passes freely through it, but if in their Summit 'tis drove back again. Hence come the Fits of easy Transmission and Refraction, that is, the same Ray of Light is in one Moment transmitted, and in the next reflected, and because the Vibrations of this Fluid are exceedingly rapid, the Rays appear to us both transmitted and reflected at the same Time. But we are now arrived to the Confines of Nature, where our Ideas grow dark and confused; these are the Barriers of Knowledge, beyond which no Force of human Faculties is permitted to proceed; I myself perhaps have run too great a Length. *Sir Isaac Newton* under the Form of Questions proposed many Things, which are probably the Recesses where

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where Nature withdraws to conceal herself from mortal Eyes. The Analogy betwixt Sound and Colour, the strange Metamorphoses of Light into Bodies, and Bodies into Light, the two-fold and surprizing Refractions of Island Cryſtal, Rock Cryſtal, and that Sort lately diſcovered in *Braſil*, will always be impenetrable Enigmas to Mankind, ſince this *Œdipus* was not able to ſolve them. How very different from the modeſt Doubts of this Legiſlator of the Wiſe, are the raſh Aſſertions of the Seducers of the Multitude. Theſe however promiſe thoſe very Men, whom they have always deceived with the ſame Flattery, to open the Temple of Truth ſo often tried in vain, in the moſt expeditious and eaſy Manner, by the Help of certain new Principles; juſt as others with certain new Systems of their own ſpread artful Nets for human Avarice, and promiſe at once to enrich a Nation, which they have always impoverished by the very ſame Schemes. The pleaſing and vain Deluſion of Hope leads ſome in Haſte to the Bank, others to the Academy. The Beginning of an Affair is generally agreeable to our flattering Expectations. The Wind is

commonly favourable to the Ship just loosed from the Port, and two bright Eyes give an agreeable Invitation at their first Appearance. The Bank at first by converting Hopes into Gold, preserves and increases it's Reputation, and Philosophy by judicious Prefaces maintains it's Honour, more successful in banishing old Errors, than substituting new Truths in their Place. Thus they who by a prudent Diffidence soon extricated themselves from the Snare, either brought back a reputable Increase of their Fortune, or were rationally delivered from their past Prejudices. But there are very few so wise as not to lose the Present, in forming Projects for the Future, or not to make the Happiness of to Day, a Step to the Misery of to Morrow. The Cheat at Length is discovered, and the first are left with their Scrutoirs full of Notes worth nothing, while the last have their Heads embarrassed with Notions of Pressure, Rotations, Globules, and Vortices, the false Coin of Philosophy. *Sir Isaac Newton*, guided by a slow yet sure Experience, promises no more than what Experience is able to perform. Where that leaves him he stops, by it's Assistance he distinguishes Truth

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Truth from Falshood, Evidence from Probability, and in the Extent of his own, discovers the Limits of the human Understanding. Are not the Rays of Light (says Sir *Isaac Newton*) very small Bodies of different Sizes, the least of which make *Violet* the weakest and darkest of all the Colours, and more easily diverted by the attractive Force of the Prism from the right Path? And the rest, as they are bigger and bigger, make the stronger and more lucid Colours, *Blue, Green, Yellow,* and *Red*, and are more difficultly refracted, in Proportion to the greater Strength of the Colours, and the larger Size of the Bodies that compose them? It is certain that the Rays of Light differ from each other in Colour, Refrangibility, and the Force with which they strike our Senses. *Scarlet* dazzles the Sight, the *Azure* of Heaven languidly moves it, and the *Verdure* of a Meadow strikes it with a very pleasing Sensation.

Only one of these Differences, said the Marchioness, had been sufficient to make an ordinary Philosopher put an absolute Difference in the Size of the Particles of Light, whereas two or three are hardly

enough to supply ours with a Conjecture.

In the vast and unlimited Perspective of Nature, answered I, there are Objects that we are for ever condemned to see languid and confused, without hoping that any Telescope can make them appear either less distant or more distinct. The Moderation of our Philosopher, in never affirming any Thing to be true which was not demonstrated by Observation, may serve for an Example to the most rash Assertors. Who could have more Reason to think himself capable of ascending Heaven, or bringing the Secrets of Nature in Triumph from thence, than Sir *Isaac Newton*, who, poised upon the Wings of Geometry, could take his Flight through immense Spaces, till then impenetrable to human Curiosity?

What a strange Condition, replied the Marchioness, is ours! We know what Size in a Particle at a great Distance from our Sight is necessary to reflect a certain Colour, but what is this Colour itself which we have always immediately before our Eyes? Hardly can we form any Idea of it by a feeble Conjecture: In one Case we have the Sight of a *Lynx*, in the other we are absolutely blind. There our Senses are refined

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refined beyond what we could have expected; here they seem to abandon and fail us all at once.

There are some Persons, answered I, who have believed that the many Difficulties which attend our little Degree of Knowledge, the great Number of Systems, the various Emblems of human Ignorance, and that continual tantalizing which Philosophers suffer in their Searches after Truth, proceed from no other Cause than our Want of a sixth natural Sense, which might reveal a great Part of what is at present hid from us, and escapes perhaps those five Senses given us by Nature to lay hold on external Objects, and bring them to the Mind. As there are certain Animals among us, who by Virtue of Senses, of which we perhaps have no Knowledge, foresee the Change of the Seasons, and Approach of the Morning, and without having read *Dioscorides* or any other Botanist, can, amidst a thousand others, distinguish that salutary Herb that cures their Hurts; who knows but in some other System (in the World of Jupiter perhaps) there may be Animals, which, more sharp-sighted than our Philosophers, may discover the Size of those

those Particles that compose the Variety of Colours, and in what Manner, without the Assistance of Ropes and Pullies, they may attract Saturn at a Distance of more than three hundred and fifty Millions of Miles? But in Return, as in that Planet, which is not depopulated by the Rage of War, the Inhabitants have no Idea of the Pleasures of Love; so, according to the agreeable Historian of these Worlds, every Thing is diversified and put in a just Balance: Those People who are thoroughly acquainted with the Nature of Colours, may perhaps want the Sense proper to give them a Perception of the most agreeable Harmony of those Colours upon the Cheeks of their *Cbloes*, and though perfectly skilled in the Attractions of the Planets, are perhaps insensible to the more pleasing Attractions of Beauty, which are preferable to any Speculation whatever. But however it be with Regard to our present Speculation, the^y most vain perhaps of all others, it is not for our Advantage to seek Occasions to put us in Mind of our Defects, nor be so ingenious in tormenting ourselves. We shall not be destitute of either Knowledge or Pleasure, if we make a good Use of the Senses fallen

to

to our Lot. Though you know nothing wherein consists the Nature of *Light* and *Colours* but by Conjecture, there will not perhaps be wanting some Persons to affirm, you know much more of it than is proper for a Lady. The Fault will be thrown entirely on me, who upon those few Verses which gave Occasion to our Subject, have made you a Comment, long enough for a Poem upon the *Newtonian* Philosophy. It will be well for it, if you dissemble your Knowledge with those Persons who ridicule what they ought to learn, and if to the Science of *Natural Philosophy* you join that of the World.

What, cried the Marchioness, am I so learned that I ought to study to be ignorant? May I venture seriously to call myself a *Newtonian*?

You have already renounced your philosophical Errors, answered I. The Light of *Newtonianism* has dissipated the *Cartesian* Phantoms which delude your Sight. You are really now a *Newtonian*, and it is no small Advantage to Truth that you are so. I will some Time give a History of the fine Conquest I have acquired for her, and I am certain if I could give a just Description

scription of my fair Disciple, my Book
would never want Readers, nor true Phi-
losophy a numerous Train of Profelytes.
You shall be the *Venus* that must lend the
agreeable *Cestus* to this austere *Juno*, and
give her those attractive Charms that
will render her engaging and amiable to
Mankind.



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